MAX

2 B

bvj

HAVO|VWO TTO

Biologie voor jou

NAME AND CLASS:

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MALMBERG

bvj

2 HAVO|VWO deel B

Biologie voor jou TTO

BIOLOGIE VOOR TWEETALIG ONDERWIJS

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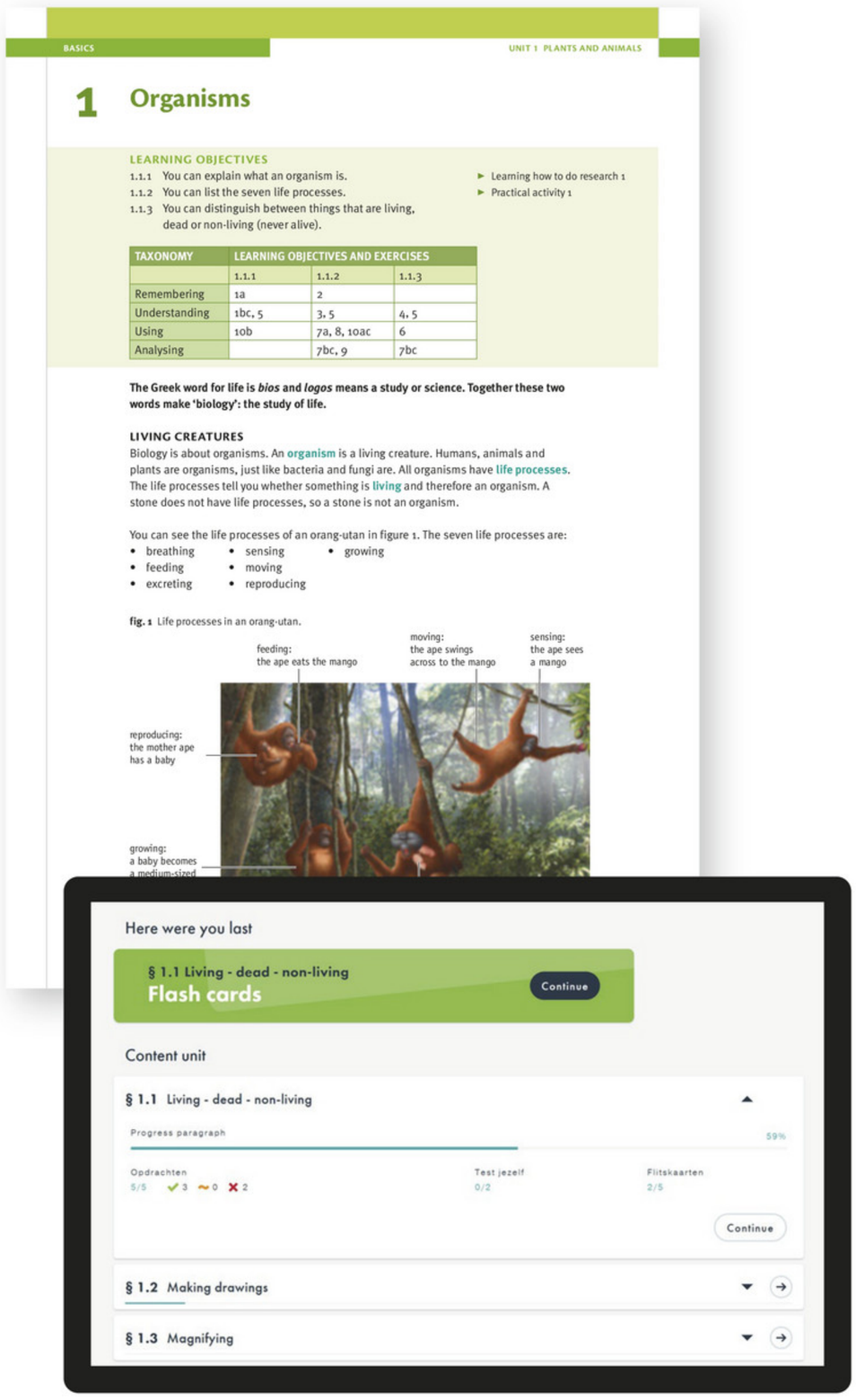
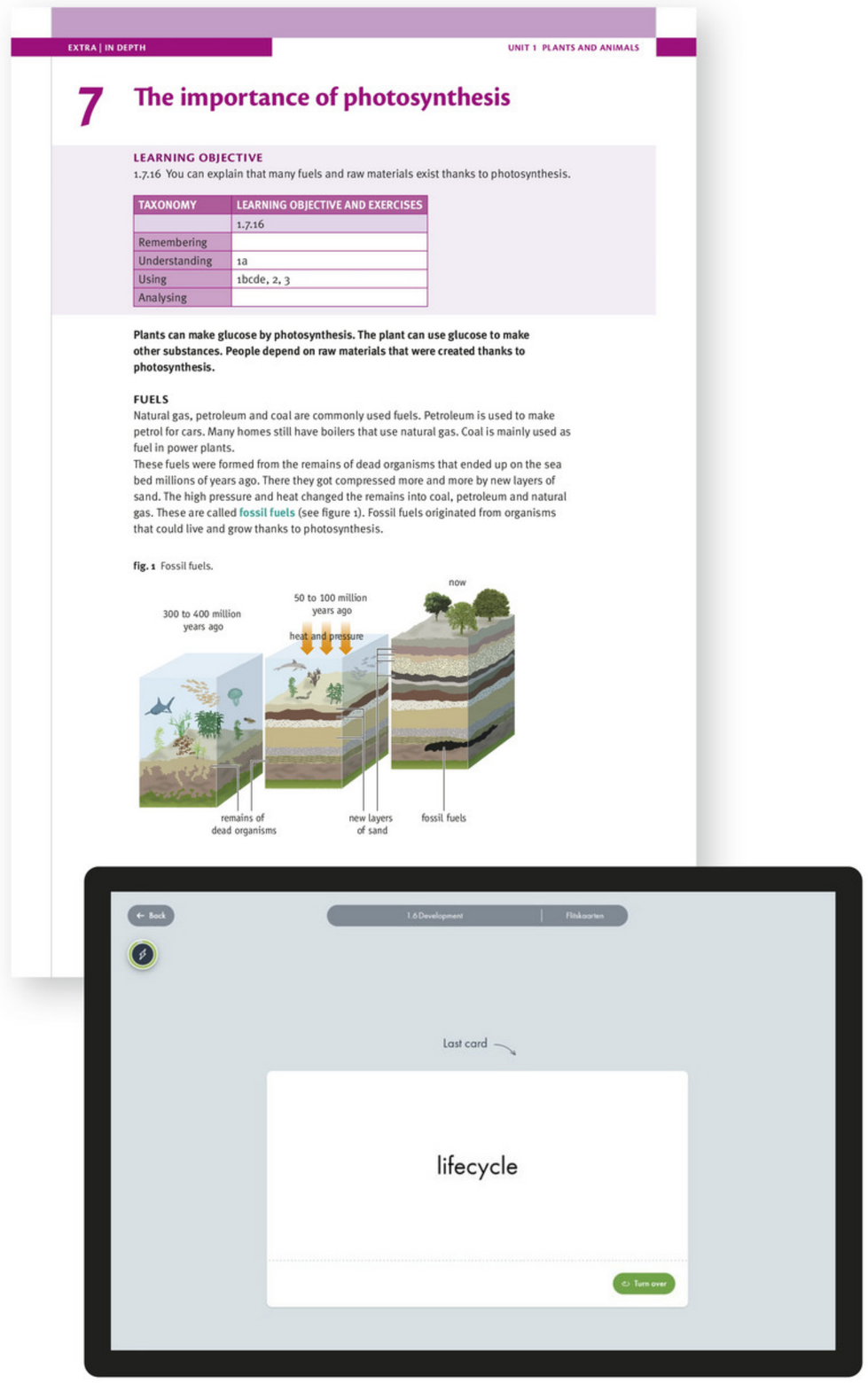
Getting started with *Biologie voor jou TTO*

Biology is all around you. *Biologie voor jou TTO* puts all the tools within easy reach that you need for experiencing, enjoying and discovering it! The introductory chapter first tells you what biology is about, why the subject is important and what you can do with it.





Work in your book *and* work online!

There are two books for each school year plus an online learning environment. Your teacher will decide what you do online (with a laptop, tablet or phone) and what you do in your book.
Each unit is split up into a Basics section, an Extra section, practical activities and a closing section. Learning objectives are always given at the start, telling you what you are going to learn and what level of taxonomy you will be using in the practical activities for the material you have learned. You can do the Extra sections if you want to know more or are feeling curious or have some spare time. In the activities section, you will do exercises and learn how to study and do research.

The advantages of working online

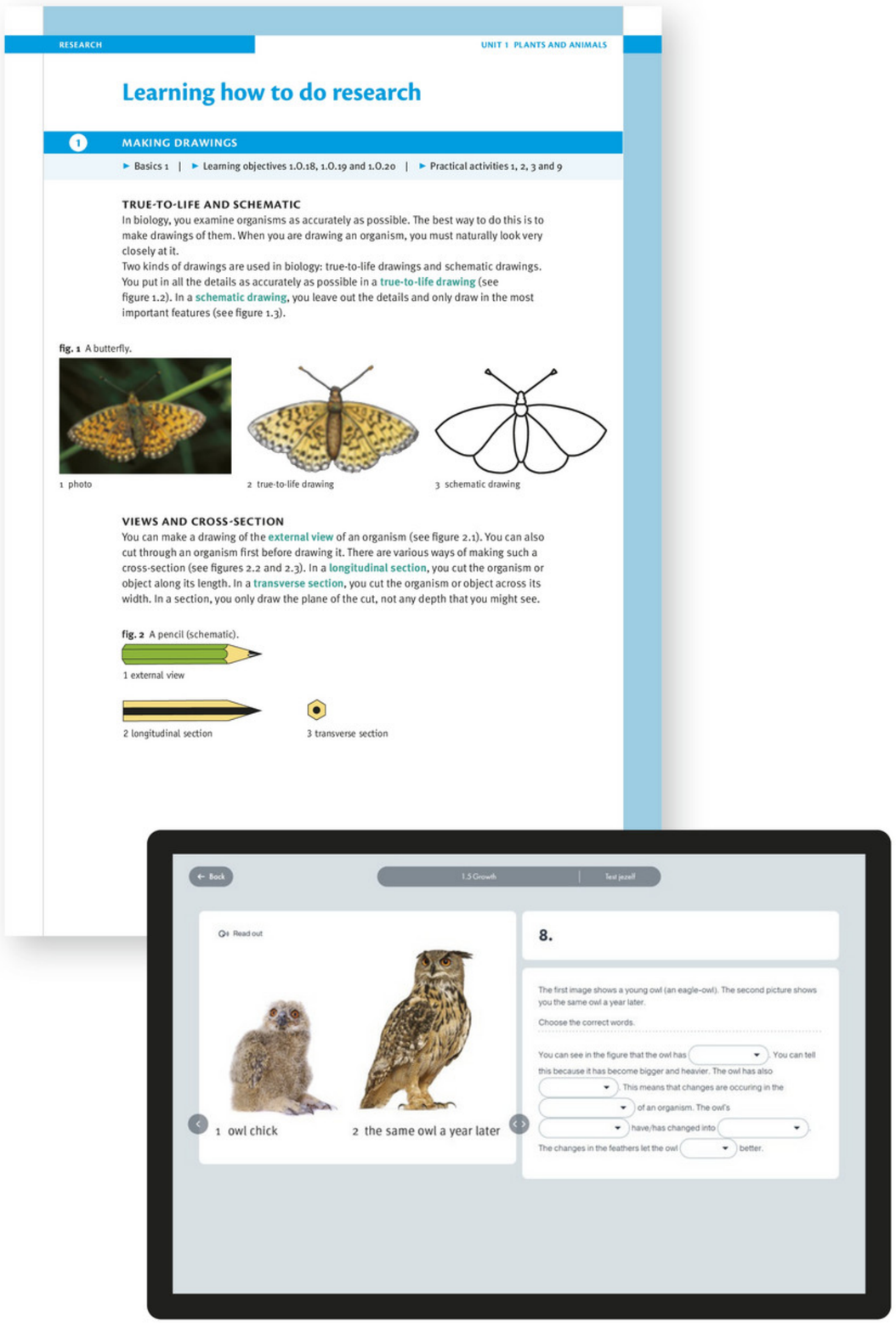
- You quickly see what you are doing correctly and what you are doing wrong.
- You get feedback on your answers straight away.
- You can watch video clips and animated clips.
- You learn the concepts and test yourself using the *Flash cards*.
- You can use the *Test yourself* sections, the practice test and the diagnostic test to see if you have understood the material.
- You can work at a higher or lower level or for a different school year.
- Your teacher will monitor how you are doing.

How it fits together

There is a section called *How it fits together* at the end of each Basics section and after all the Basics sections as a whole. These are in an orange frame. The way things fit together shows you why the course material is important in the world around you. You also learn to see connections between the information in the various Basics sections.

Good preparation for the test!

The units end with a closing section (Summary). This is also where you can find the ***Flash cards*** for learning all the concepts. There is also a ***Diagnostic test***. If you are not sure that you understand the material well enough, you can do the ***Test yourself*** section or the ***Practice test***.



The advantages of the book

- You get a quick overview of what you will be learning.
- You can read the longer texts on paper.
- You can annotate the text and add remarks.
- You will be making drawings and adding colour yourself, which helps you remember things better.

Meaning of the symbols

This exercise is best done in your book.

Go to the online learning environment for some useful extras.

This is how long this practical activity will take.

This exercise is extra challenging.

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TO FINISH

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4 Reproduction and sexuality

After about your tenth birthday, your body starts to change. Sexuality is going to start playing a role in your life. A boy will start producing semen and a girl will have her first period.

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1 Puberty

LEARNING OBJECTIVES

4.1.1 You can list primary and secondary sexual characteristics.
4.1.2 You can describe the physical and emotional changes during puberty.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES	
	4.1.1	4.1.2
Remembering	1abc	3
Understanding	1d, 4	2, 4, 5b
Using	5a, 6a	7a, 8, 10bc
Analysing	6b, 9b	5c, 7b, 9, 10ad

People are all different from each other. Men mostly look different to women and boys are different from girls. There are all kinds of differences between two girls or two boys as well.

SEXUAL CHARACTERISTICS

You can usually tell whether a baby is a boy or a girl the moment they are born. This is called the baby's **sex**. The anatomical characteristics that define the sex are called the **sexual characteristics**. The sexual characteristics that are already present at birth are known as the **primary sexual characteristics**. Figure 1 shows the primary sexual characteristics:

- You can tell a child is a boy by the penis and scrotum.
- You can tell a child is a girl by the vulva (labia, clitoris and vaginal opening).

Just occasionally, it may not be immediately obvious from the external characteristics whether the baby is a boy or a girl. That happens about once a week in the Netherlands. The baby then has both male and female sexual characteristics, or the sexual characteristics differ from the norm. This is called **intersex**. It sometimes only becomes clear in puberty that a person is intersex.

After about your tenth birthday, changes start taking place in your body. Young people start **puberty** on average somewhere around age eleven. During puberty, you will experience physical, mental and behavioural changes.

fig. 1 Primary sexual characteristics are present from birth.

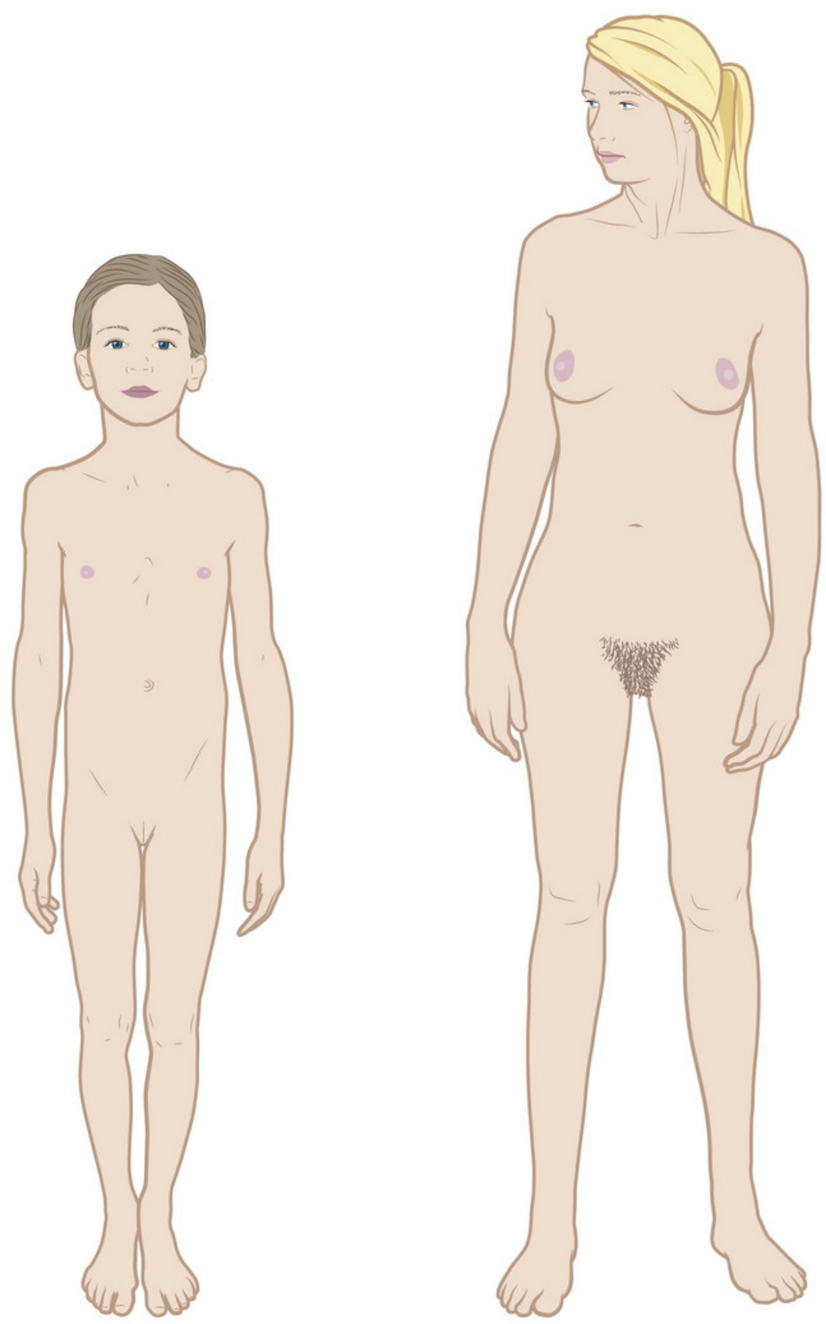
PHYSICAL CHANGES

You will be able to see some of the **physical changes** taking place in your body. For example, from about age 12 you will start to grow quickly (the growth spurt). Many young people get hair under their arms and around their sexual organs (pubic hair). There are other physical changes that you will not be able to see, for instance that the reproductive organs inside your body will start developing.

The sexual characteristics that appear in puberty are called the **secondary sexual characteristics**. In figure 2, you can see that a woman has a more rounded body shape than a girl. During puberty, the woman's breasts have grown and the hips have become broader.

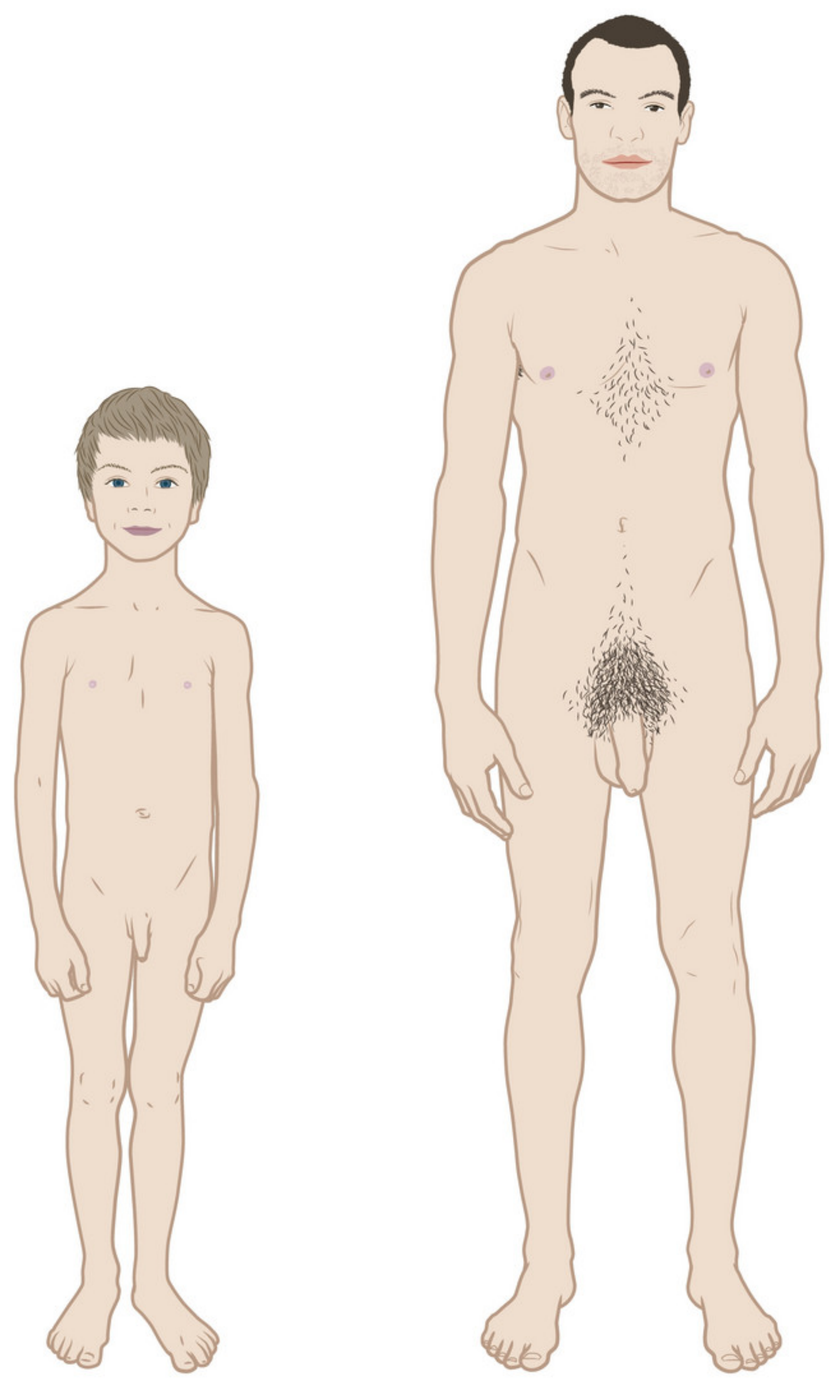
Figure 3 shows you the secondary sexual characteristics in a man. The adult man has a more muscular build than the boy. In puberty, his beard and chest hair have started to grow. His voice has also become lower ('broken'). Both men and women get pubic hair during puberty. Because the shape is different, that can also be seen as a secondary sexual characteristic.

fig. 2 Sexual characteristics of women.



1 primary sexual characteristics of a girl
2 secondary sexual characteristics of a woman

fig. 3 Sexual characteristics of men.



1 primary sexual characteristics of a boy
2 secondary sexual characteristics of a man

YOUR OWN BODY AT YOUR OWN PACE

The physical changes during puberty do not all happen at once. Some changes appear early in puberty, others much later on. In some people, some of the changes may not happen (or may be almost completely absent). Not all men get chest hair, for example, and women do not always get large breasts or wide hips. This means that people's secondary sexual characteristics can vary a lot.

Figure 4 lists some of the changes and the ages the developments can start in boys and in girls. As you can see, there is quite a range of ages. Any boy or girl will develop at their own pace. So there is no need to worry if you are a bit 'late' or 'early' developing, compared to the average.

fig. 4 Timelines for the development of boys and girls.

The results of the physical changes are different for everyone too. Some boys might get a long, thin penis and others a short, thick one. Some girls get large breasts, others get smaller ones. In many women, the two breasts are not exactly the same size, and the size and shape of the nipples varies between people too. Some boys get hair everywhere and others don't.

The way your body develops is special and unique to you. Nobody else has exactly the same body as you. In the media, you often see images of 'perfect' people, but they aren't real. The makeup has been put on by professionals, they may have had their bodies altered, or the photos may simply have been 'tweaked' to make them look more 'attractive'. Normal bodies look different from that – and very different from each other. Have a good look around at the swimming pool. Everyone is built differently.

EMOTIONAL CHANGES

During puberty, you will also have **emotional changes**. You are slowly growing up. This progresses more quickly for some people than for others. On average, girls mature more quickly than boys. These mental or emotional changes affect your thoughts, your feelings, your independence and your social life.

In puberty, you get more interested in other people. Sexuality is going to start playing a more important role in your life. You may feel strongly attracted to one special person and may then fall in love with them (see figure 5). You then try to catch that person's attention and be particularly nice to them. If that other person falls in love with you as well, you will feel very happy. You may then start a special relationship with them.

The social side of things changes for you as well. In puberty, you will start acting differently towards your parents. You don't want to be treated like a little kid anymore. Sometimes you may get extremely angry about nothing. You may behave differently with your friends too. You may perhaps have preferred to have one best friend before, but now feel much more at ease in a group of young people.

Puberty can be fun and exciting, but you may also feel uncertain, lonely or sad. These feelings are part of puberty. As you get older, they will affect you less.

fig. 5 In love!

KNOWLEDGE

1 Sexual characteristics are the physical features that let you tell what sex someone is.

a What are the primary sexual characteristics of a man?

b Secondary sexual characteristics *arise during puberty / are already present at birth*.

c What are the secondary sexual characteristics of a woman?

- ☐ A breasts
- ☐ B wider hips
- ☐ C pubic hair
- ☐ D labia
- ☐ E vagina

d What three physical changes do both boys and girls go through in puberty?

2 Study figure 4.

a The development of breasts in girls can start between ages ..... and ..... .

b Jasmine starts to develop breasts at the age of 9.
Compared with most girls of that age, that is *late / early*.

c The growth of the penis in boys starts on average at age ..... .

3 All kinds of changes take place in puberty.

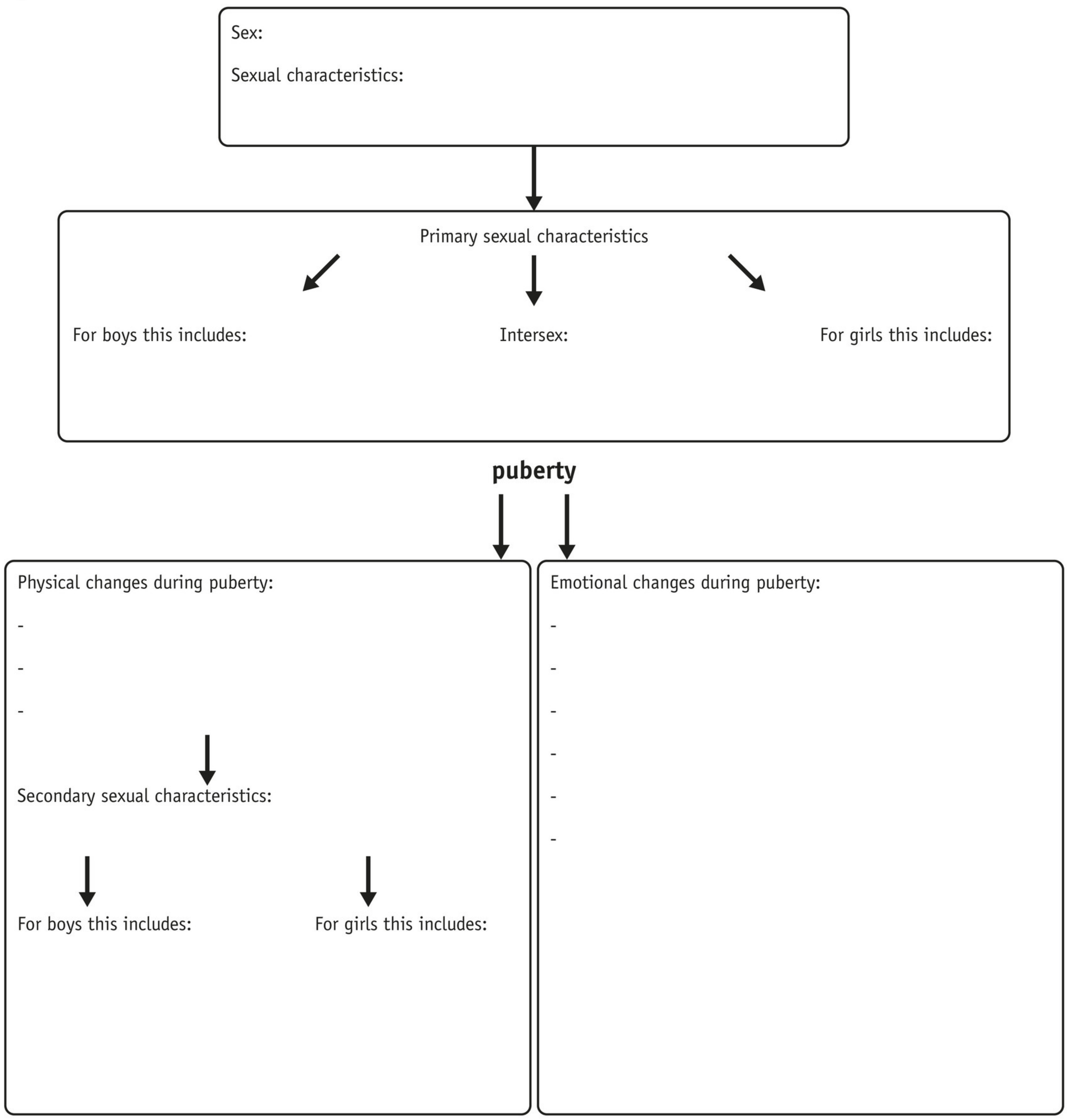
- On average, *boys* / *girls* grow up earlier.
- Not wanting to be treated as a little kid any more happens because of your *emotional* / *physical* changes.

4

Summary

Figure 6 shows a mind map for the sexual characteristics and changes during puberty. Fill in the rest of the mind map.

fig. 6



INSIGHT

5 Read the text 'Sex determination in eels' in figure 7.
Adult eels have been found with both immature ova and immature sperm cells.

a What sex are these eels? Explain your answer.

b Eels in eel farms live close to each other. The eels in an eel farm turn out to be 75% to 90% the same sex.
Which sex will most of the eels be? Explain your answer.

c Eels swim to the Sargasso Sea to reproduce. Female eels grow much larger than the males. They need the extra bodyweight for the return journey and for producing eggs. That needs a lot more food reserves than producing sperm cells does.
Explain how the development of an eel to become male or female is related to the population density of the waters they live in.

fig. 7

Sex determination in eels

Young eels are born in the Sargasso Sea and they then spend about a year swimming to get to freshwater areas in Europe. The sex of each animal is only determined then. Whether a young eel becomes male or female depends (among other things) on the population density: if a lot of eels live close by each other, there are more males; if there are fewer eels living together, more of them become females.

Source: www.nemokennislink.nl.

6 Read the text 'Hair perfume' in figure 8.

a Why are pubic hair and armpit hair a sign that someone is sexually mature?

b In the nineteenth century, it was a custom in England to cut off a bit of pubic hair and give it to a lover in a small box or locket.
Explain why the scent in the sweat from the apocrine sweat glands plays a major role in sexual attraction.

fig. 8

Hair perfume

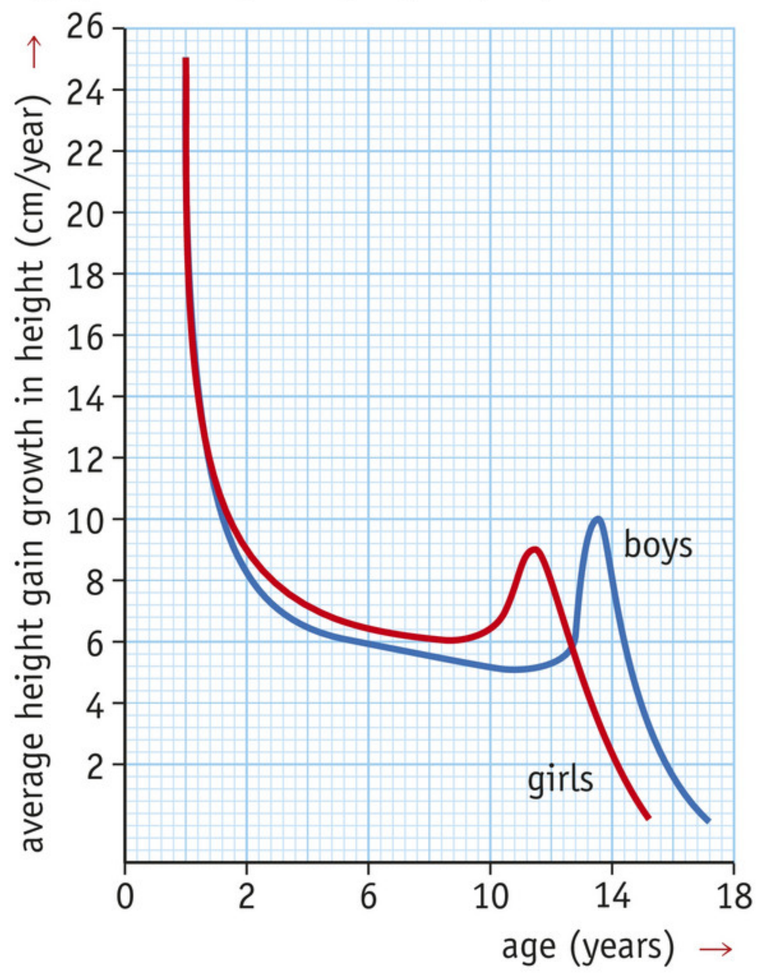
There are sweat glands all over your body. They produce sweat to cool you down. Apocrine sweat glands are only found under the arms, in the groin, around the anus and around the nipples. The glands only start to work in puberty. They produce sweat with a scent, an odour that is unique to the individual and plays a role in attracting a partner. Puberty is also when public hair and armpit hair start to grow. That provides an extra surface area for the sweat, so that the scent can spread better.

7 Study figure 9.

a Do boys or girls grow faster on average during puberty? Explain your answer.

b Are there also girls who grow faster during puberty than some boys? Explain your answer.

fig. 9 Average height gain per year.



8 On his eighteenth birthday, the YouTuber Jeroen van Holland looks back on his early teenage years. In a video clip, he discusses why it is sometimes awkward to be a teenage boy.
Which mental developments are involved in the behaviour Jeroen is discussing?

A Doing things such as smoking and drinking alcohol because of peer pressure. ○

B Being unable to style your hair the way you want or find the right things to wear. ○

C Swearing at your mother. ○

D Being affected by mood swings. ○

E Getting an erection at the wrong moments. ○

○ 1 You start behaving differently towards friends and friendships are more often in groups.

○ 2 You start acting differently towards your parents.

○ 3 Feeling uncertain about your appearance.

○ 4 You can sometimes feel angry, uncertain, lonely or sad.

○ 5 Sexuality starts to play an important role in your life.

+ 9 People throughout the world think that certain physical characteristics of others look good or are sexually attractive, such as smooth and supple skin, a healthy and well-functioning body and hair with volume.

a Explain why many people would see others with those characteristics as a suitable partner for having children with.

b Well-developed secondary sexual characteristics such as wide hips or broad shoulders are also found sexually attractive by people all over the world. Explain what signal this involves.

HOW IT FITS TOGETHER the living world

WHERE IS YOUR 'COMMON SENSE'?

There are lots of changes in your brain in puberty. The developments start in the posterior brain areas (at the back) and progress during the course of puberty to the frontal lobe. Your brain's development is complete somewhere between the ages of 21 and 25. The area in the frontal lobe that is the last to undergo changes is precisely the one that controls processes such as abstract thinking, consciously making choices, understanding the consequences of decisions, planning properly and setting priorities. Because an adolescent cannot always do that very well, it sometimes looks as if you have lost your 'common sense'. You may for instance still need your parents to get your homework planned properly or to do your household tasks.

Adolescents' brains can learn lots while they are still developing, though. If you train yourself to do something well during puberty, you will benefit from it for the rest of your life.

fig. 10

10 Read the text 'Where is your "common sense"?'.
During puberty, you may for example need your parents to help you plan things. Because you are undergoing mental changes as an adolescent, you will often have arguments then.

a What mental change makes these arguments happen?

b Is having arguments with your parents social behaviour? Explain your answer.

c A blog advises teenagers' parents to get their children interested in various sports, music and other cultural activities so that they can develop their talents and to encourage curiosity about new things.
Why is puberty a good time to encourage this?

d One of the mental changes in puberty is that sexuality starts to play an increasingly important role. You may for instance feel attracted to other people.
Is that determined by internal or external stimuli, or both? Explain your answer.

Go to the *Flash cards* and the *Test yourself* section.

2 A woman

LEARNING OBJECTIVES

4.2.3 You can give the parts of the female reproductive system with their functions and characteristics.

4.2.4 You can describe the menstrual cycle.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES		
	4.2.3	4.2.4	4.1.1*
Remembering	1abde	2bcde, 3c	
Understanding	1c, 5	2a, 3abde, 4, 5	
Using	7a, 8a, 9d	6, 7a, 9d, 10ac	
Analysing	7b, 8bc, 9abc	10b	9abc

* You can find this learning objective in another Basics section.

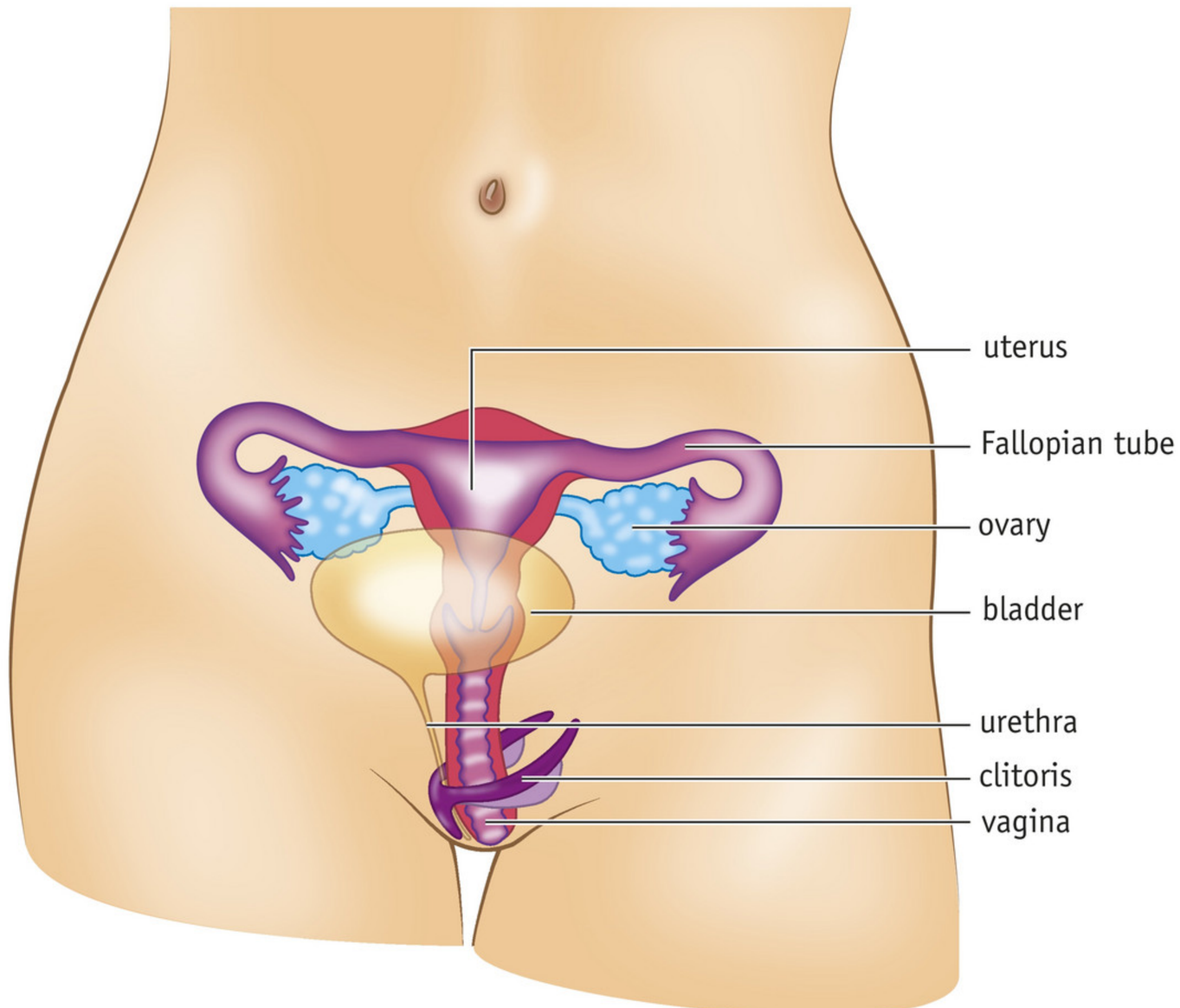
There is not much of a woman's reproductive system that can be seen from the outside. In a woman, most of the sex organs are in the abdomen.

WOMB AND OVARIES

Figure 1 is a photo of a naked woman. Most of the organs of the reproductive system are in the lower abdomen, below the belly button (see figure 2).

fig. 1

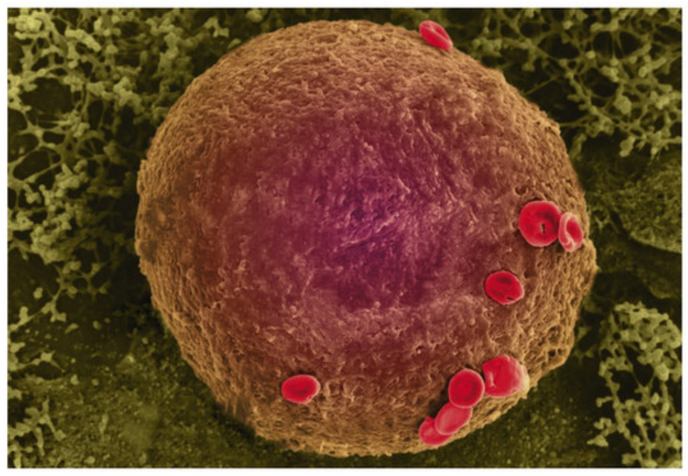
fig. 2 The female reproductive system (schematic).



A woman has a **uterus** (or **womb**) and **ovaries**. Each ovary contains hundreds of thousands of immature ova. The **ova** (or egg cells) are the female sex cells. The immature (unripe) egg cells are present from birth. When a girl starts puberty, the unripe egg cells start developing.
From puberty onwards, an egg cell (ovum) matures approximately once a month. The ovum is then released from an ovary. This is called **ovulation**. The ovum then passes down the **Fallopian tube** into the womb. An egg cell only lives for twelve to twenty-four hours after ovulation. It then dies and the residues will be absorbed into the bloodstream. This happens in a Fallopian tube.

If the egg cell is fertilized after ovulation by a sperm cell from a man, it can stay alive. The fertilized egg cell can then develop in the womb into a baby. The woman is then pregnant.

fig. 3 An egg cell with a few red blood cells (425× magnification).



Ova are the largest human cells (see figure 3). An ovum is large because it contains a lot of food reserves. Those reserves are needed for the initial development if the ovum gets fertilized.

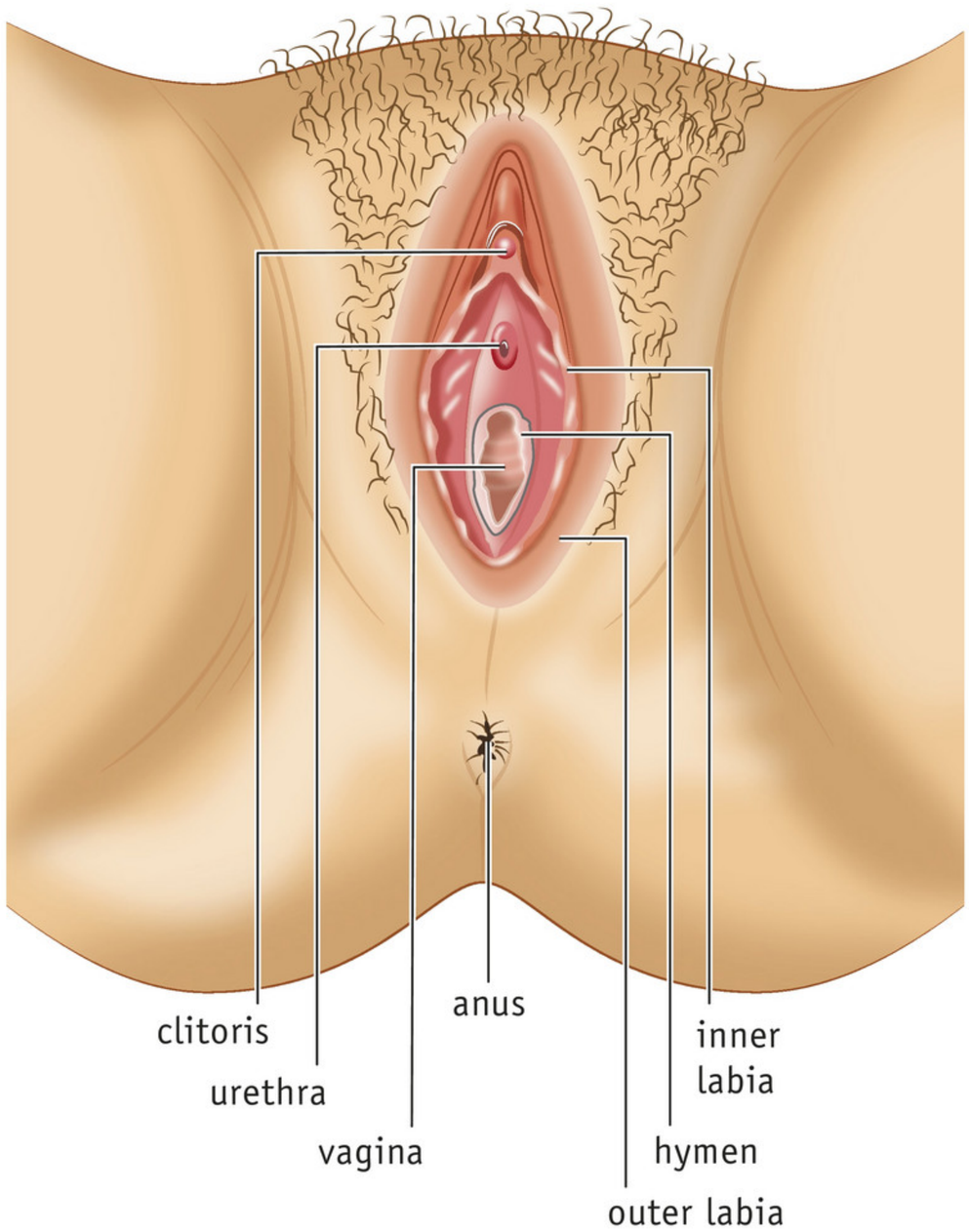
CLITORIS AND LABIA

Figure 4.1 shows you the external sexual organs (**vulva**) of a woman. The **clitoris** is sensitive to stimulation that gives a pleasant feeling. The organ is about 10 cm long and it is inside the body, beneath the labia (see figure 4.2). Only the **clitoral glans** is visible on the outside. This small 'bud', which is often simply referred to as 'the clitoris', is extremely sensitive. It is surrounded by a fold of skin called the **clitoral hood**. The clitoris also has **erectile tissue**. When a woman is sexually aroused, the erectile bodies fill with blood and become larger and firmer.

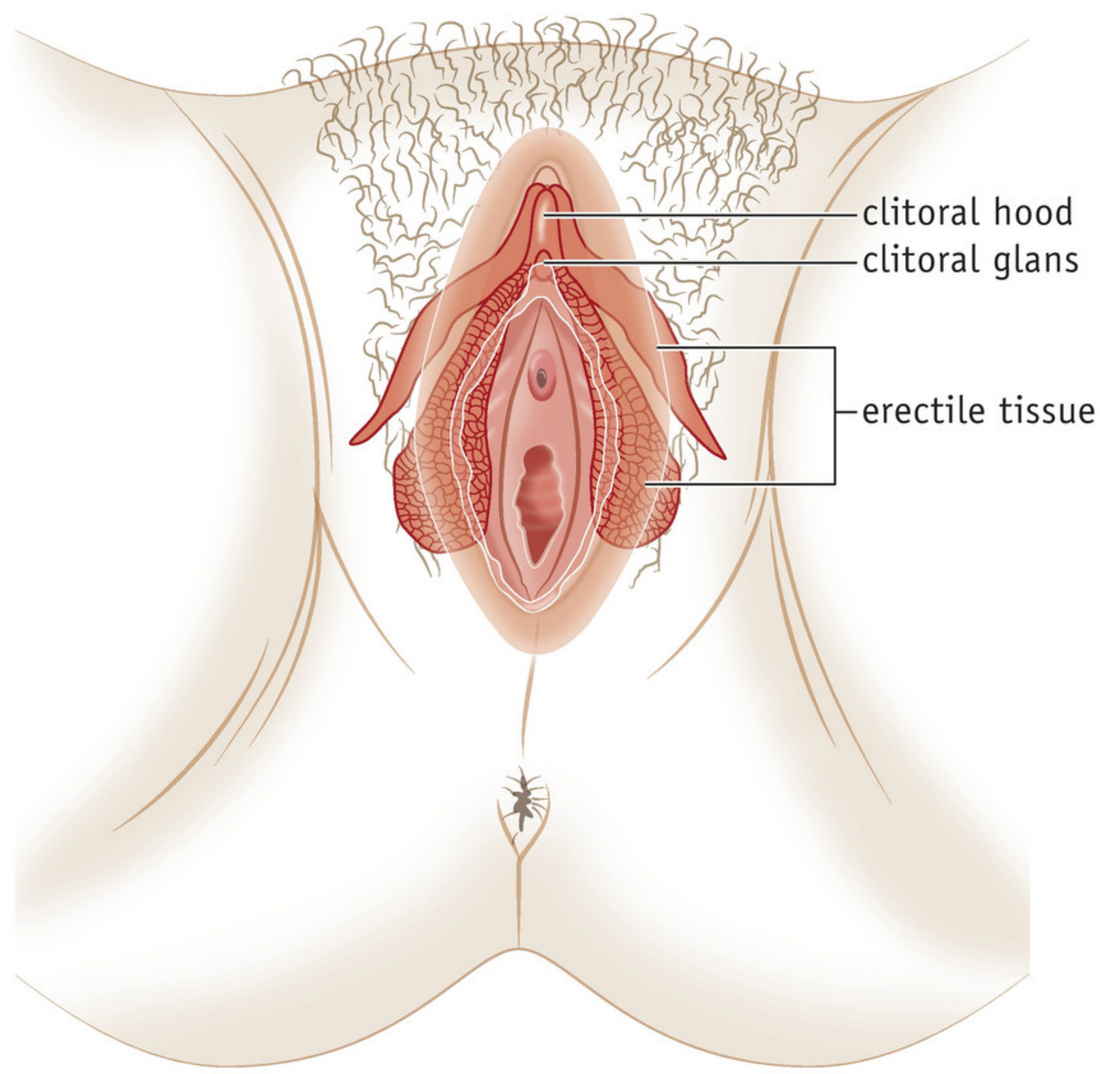
The **inner labia** are smooth, thin folds of skin that meet at the top just below the clitoris. The openings of the urethra and the **vagina** are between the inner labia. The vagina connects the vulva to the womb. There are glands in the wall of the inner labia that produce mucus during sexual arousal. This makes the entrance to the vagina moist and slippery. The **outer labia** are the folds of skin with hair on outside the inner labia. After puberty, most women's inner labia are larger than the outer.

You should wash the vulva with water every day to keep it clean. Do not use soap because that irritates the mucous membranes.

fig. 4 The external sex organs of a woman.



1 vulva



2 clitoris

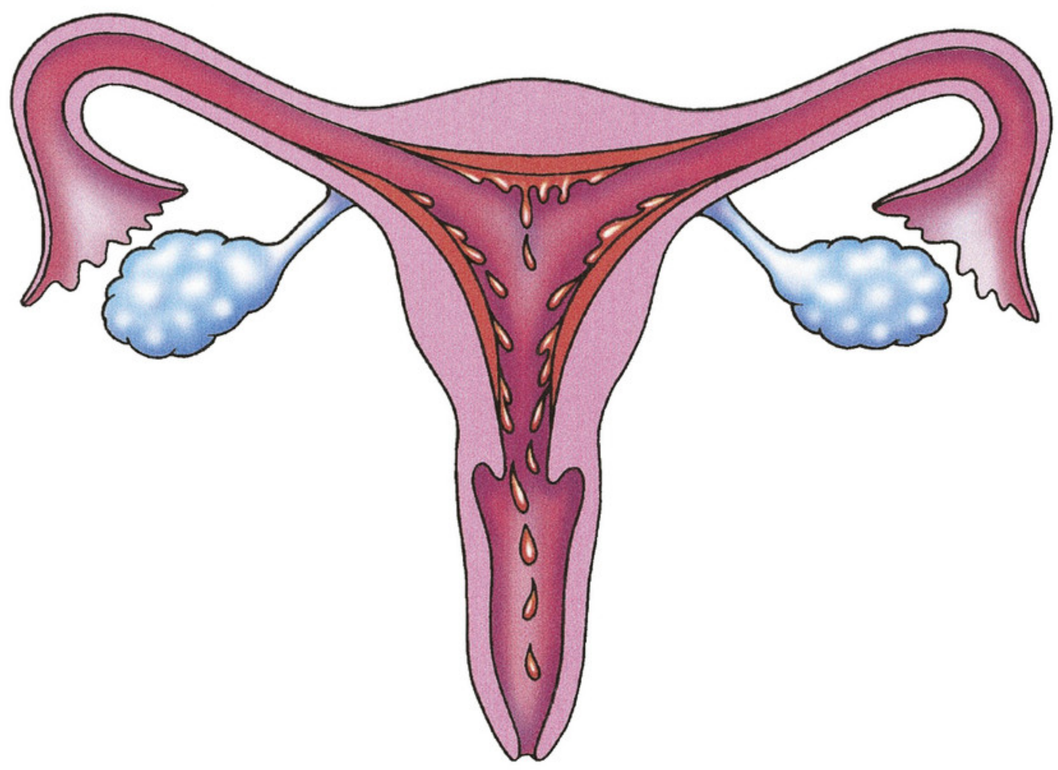
HYMEN

At the front of the vagina is the **hymen** (see figure 4.1). The hymen is a membrane near the entrance to the vagina. Some girls are born without a hymen. The hymen is not a closed membrane, though, and does not therefore have to be broken the first time that a woman has sexual intercourse; so most girls and women do not bleed 'the first time'.

MENSTRUATION

The wall of the womb consists of a thick layer of muscle that is covered on the inside with a mucous lining called the endometrium. This lining contains a lot of blood vessels. About once a month, some of the endometrium comes loose. This also releases blood. Contractions of the muscular layer of the uterine wall get rid of the pieces of lining and blood (see figure 5). This loss of part of the womb lining is called **menstruation** or having a **period**.

fig. 5 Part of the uterine wall lining and blood are carried away during menstruation.



Most girls have their first period between the ages of 10 and 16. On average, girls have their first period at age 13. In some girls and women, menstruation may last about three days and in others it may last a week. The contractions of the uterine wall may be felt as painful abdominal cramps. Girls and women can feel miserable or sad before and during their period. Some may be bad-tempered or absent-minded, or they may suffer headaches, abdominal pain, back pain or muscle pain. There are also women who are unaffected.

Pads (also called sanitary pads or sanitary towels), **tampons** or **menstrual cups** can be used for collecting the lining and the blood (see figure 6). Sanitary pads are worn inside your underwear, with the upper side against the vaginal opening (see figure 7.1). A tampon is inserted into the vagina, where it absorbs the lining and blood (see figure 7.2). A menstrual cup is inserted into the vagina, where it slowly fills up. You have to empty is, rinse it out and reinsert it every four to six hours. Sanitary pads and tampons also have to be replaced several times a day. Pads, tampons and menstrual cups come in various sizes. The size you need depends on your build and the amount of blood you lose. During menstruation, it is important to wash well (without soap) between the labia.

fig. 6 Pads, tampons and menstruation.

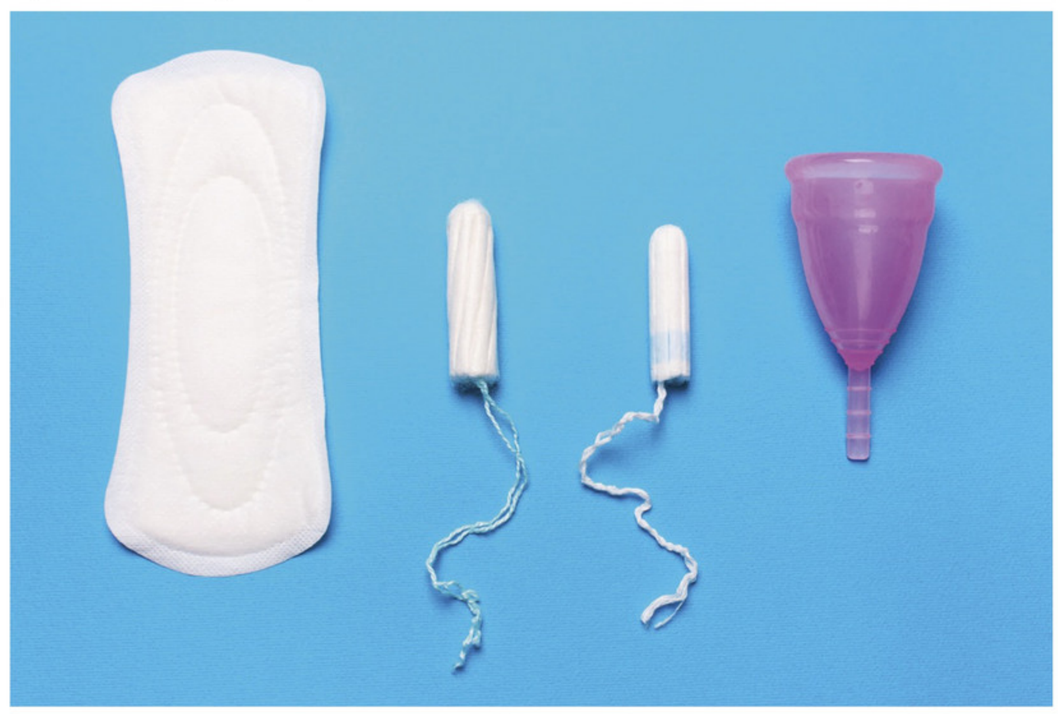
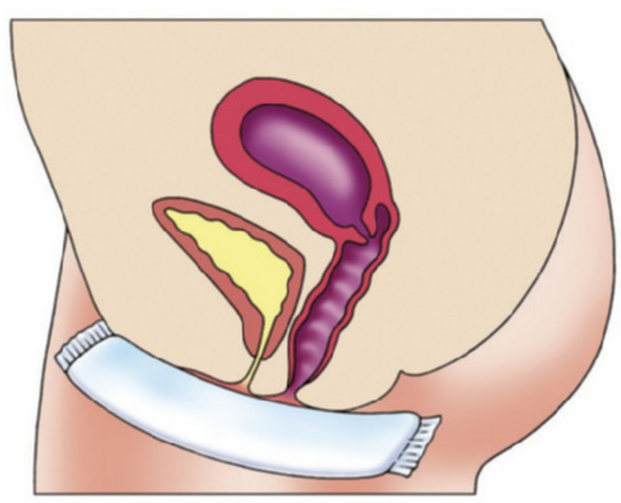
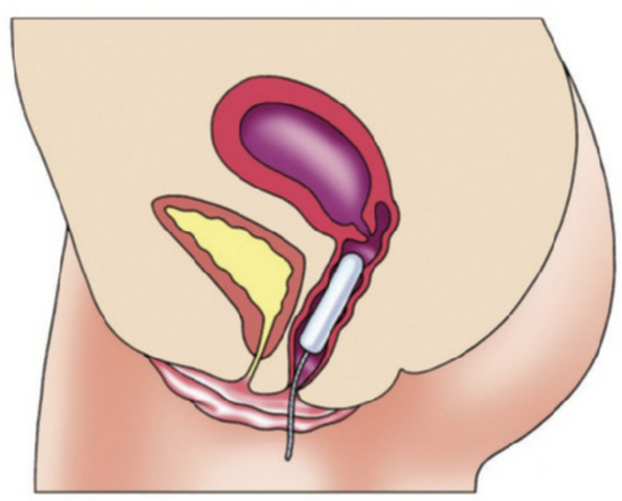


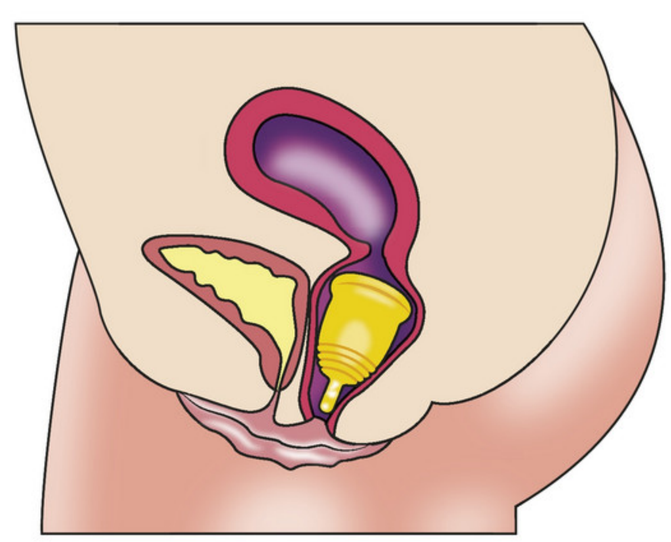
fig. 7



1 how to use pads



2 how to use a tampon



3 how to use a menstrual cup

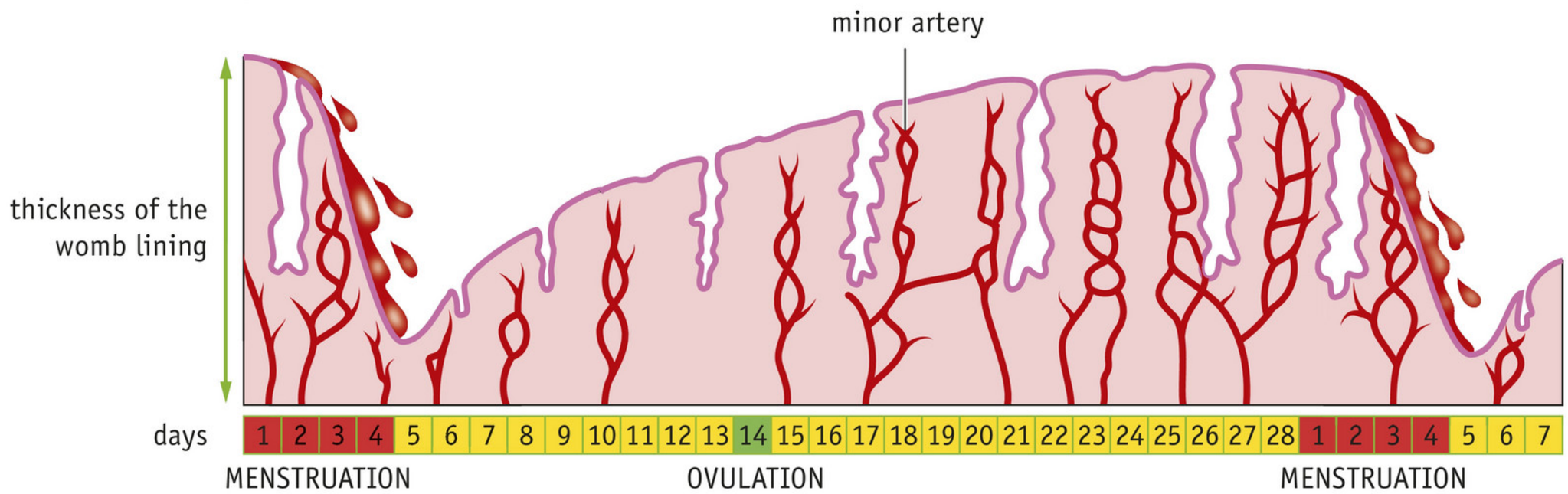
THE MENSTRUAL CYCLE

After menstruation, the endometrium builds up again. The lining becomes thicker and it contains more blood vessels. This is how the womb is preparing itself for a possible pregnancy. Figure 8 is a diagram showing the thickness of a woman's womb lining over the course of five weeks.

Ovulation occurs roughly fourteen days after the start of menstruation. If the ovum is not fertilized, the next menstruation begins on about the 29th day. The repeated build-up and elimination of the endometrium is called the **menstrual cycle**.

When a girl has just started menstruating, the cycle is often irregular; it mostly becomes more regular after a couple of years.

fig. 8 The womb lining of a woman over the course of five weeks.



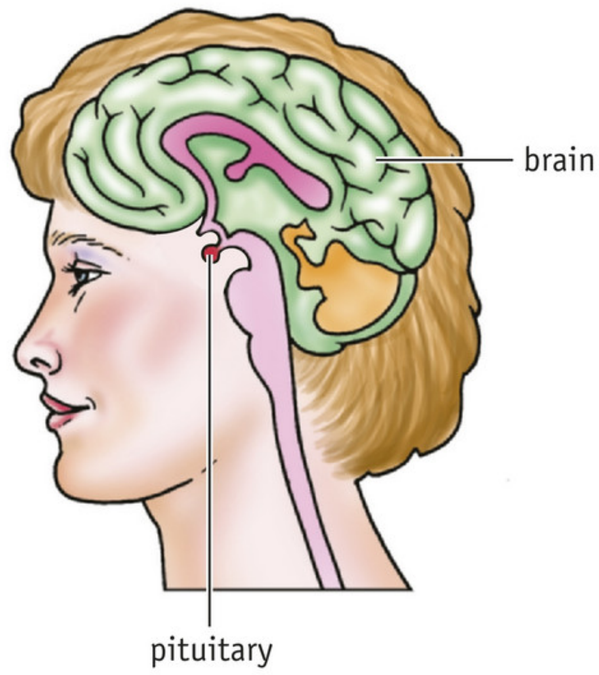
HORMONES

Hormones are substances that control the functioning of organs. Endocrine glands secrete their hormones into the bloodstream. The hormones end up throughout the body via the blood. A hormone only has an effect in tissues and organs that are sensitive to that hormone.

The **pituitary** is an important endocrine gland for the sex organs. It is located at the underside of the brain (see figure 9). In puberty, the pituitary gland starts to produce stimulatory hormones. Under the influence of these hormones, the egg cells start developing in the ovaries.

When a woman reaches about 50 years of age, less and less of the hormones is produced. The woman then enters the **menopause**. After the menopause, no more egg cells ripen and the woman can no longer become pregnant. She then no longer has periods.

fig. 9 Location of the pituitary gland.



KNOWLEDGE

1 Figure 10 shows a drawing of the reproductive system of a woman.

a Write down the names of the numbered parts.

b Colour in the various parts in the drawing. Use a different colour for each part.

c Add a red line showing where the hymen can be.

d Figure 11 shows a drawing of the clitoris.
Write down the names next to the numbered parts.

e Write down name of the corresponding organ for each of the following functions.

- These transport the egg cells. .....
- This is where a fertilized egg cell can develop into a baby. .....
- This is where the development of the egg cells takes place. .....
- The endometrium and blood are transported away through this. .....
- There are glands in the wall here that produce mucus during sexual arousal. .....
- Is sensitive to stimulation that gives a pleasant feeling. .....

fig. 10

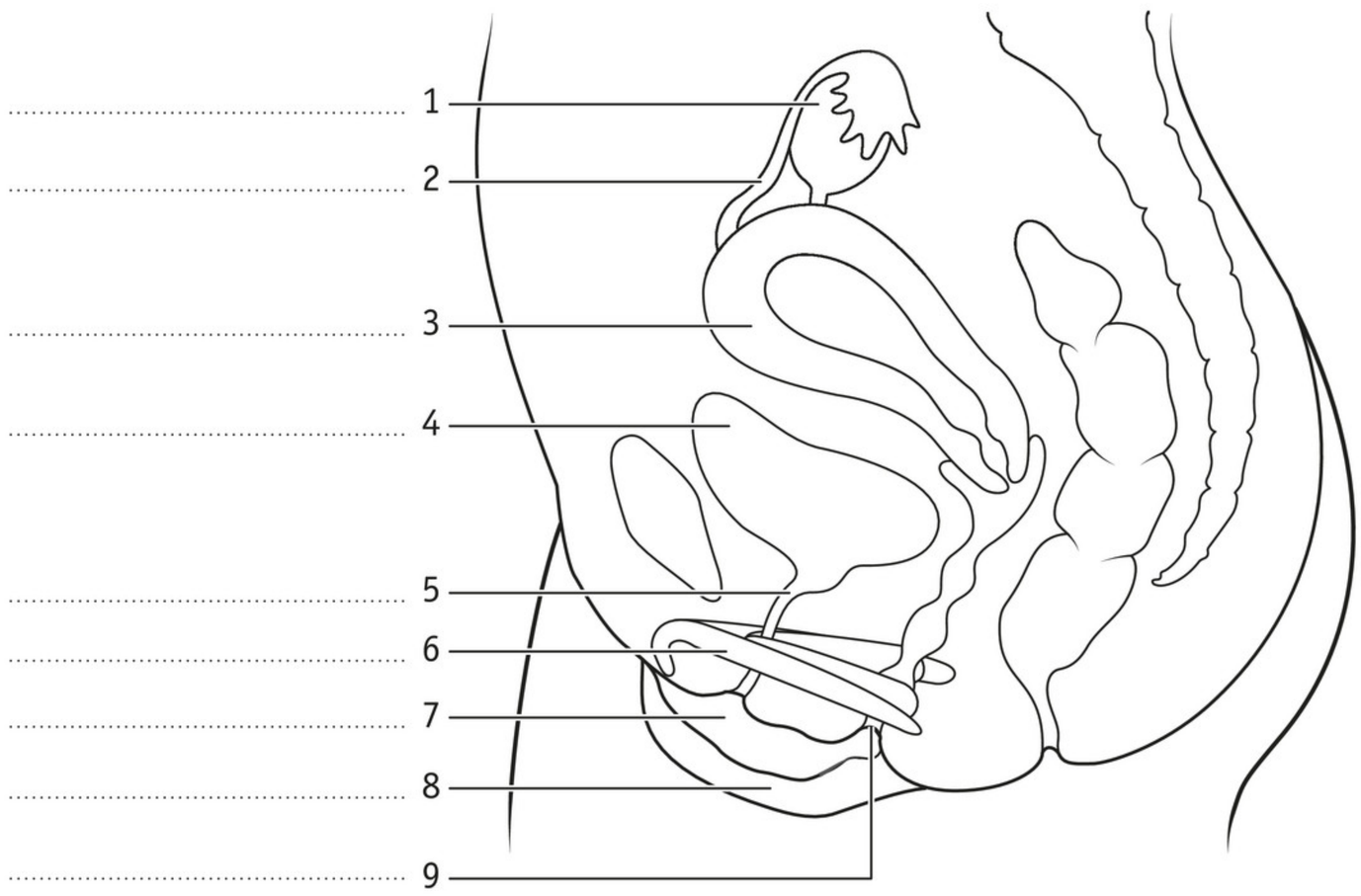
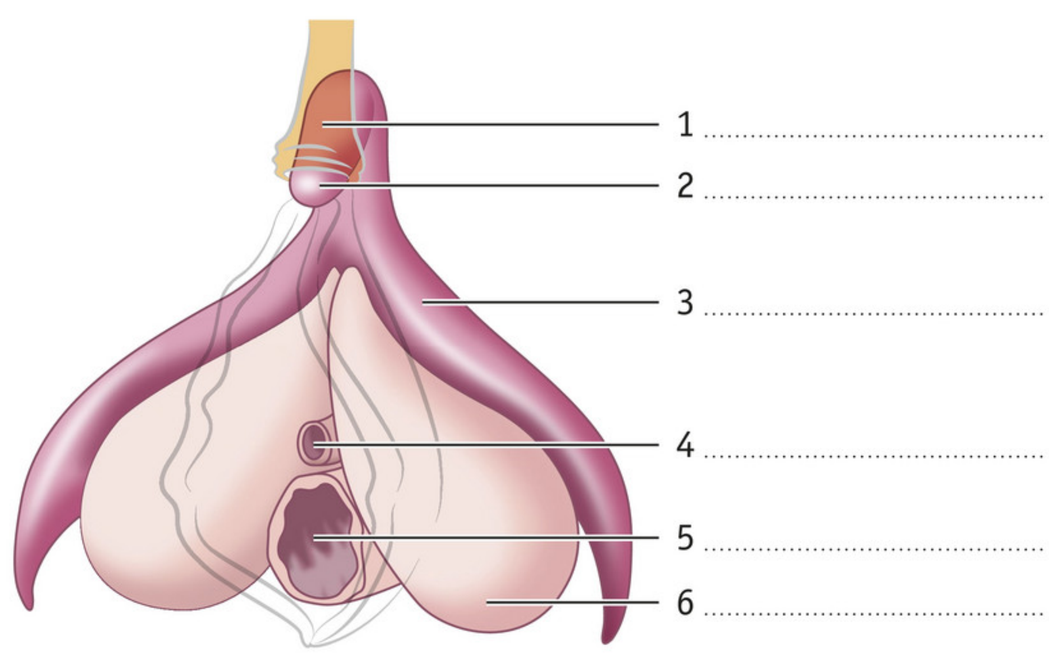


fig. 11



2 The ova (or egg cells) are the female sex cells.

a Mature ova *appear from puberty / are present from birth*.

b What do we call it when the an egg cell is released from an ovary?

c When does ovulation happen in a women who is fertile?

- ○ A every 12 to 24 hours
- ○ B about once every two weeks
- ○ C about once a month

d An egg cell is large because it contains a lot of food reserves.
What is this stock of food needed for?

e An ovum that does not get fertilized will die.
What happens to the remains of the egg cell?

- ○ A The remains leave the body during menstruation along with the womb lining and blood.
- ○ B The remains are absorbed into the bloodstream in the womb.
- ○ C The remains are absorbed into the bloodstream in the Fallopian tube.

3 Most girls have periods from puberty onwards.

a Put the developments in a woman's body in the correct sequence.

..... If the ovum is not fertilized, the endometrium is rejected (menstruation).

..... A mature ovum is released during ovulation.

..... During puberty, the pituitary gland secretes stimulatory hormones.

..... Under the influence of hormones, the egg cells start developing in the ovaries.

..... Stimulatory hormones reach the ovaries through the bloodstream.

b When a woman reaches about 50 years of age, the menopause starts.
Which of the following statements about women in the menopause are correct?

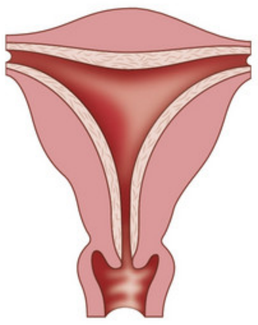
- ☐ A No more ova ripen in the ovaries.
- ☐ B the start producing increasing amounts of hormones.
- ☐ C They have a period every month.
- ☐ D Pregnancy is no longer possible.

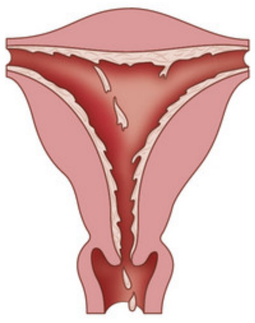
c How is the womb lining plus blood removed from the womb?

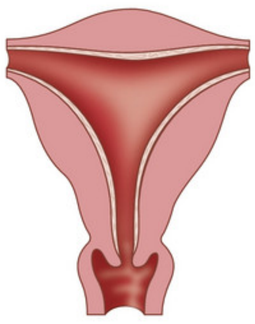
d Connect each description with the corresponding method of collecting menstrual blood.

A	Inserted into the vagina, where it slowly fills up.	○	○ 1 pads
B	Worn inside your underwear, with the upper side against the vaginal opening.	○	○ 2 menstrual cup
C	Inserted into the vagina, where it absorbs the lining and blood.	○	○ 3 tampon

e Which moments of the menstrual cycle match each of these cross-sections of the womb?

A 

B 

C 

1 shortly after menstruation

2 during menstruation

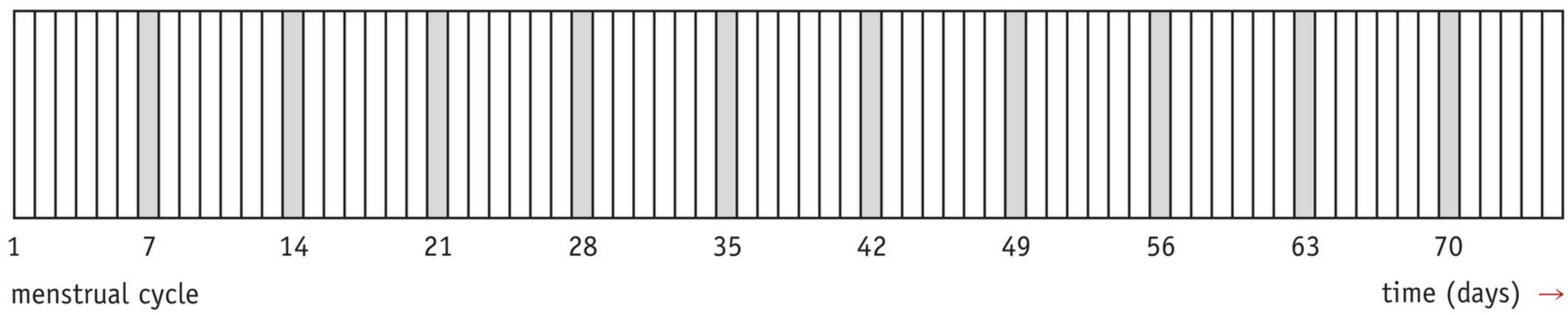
3 during ovulation

4 Figure 12 shows a timeline covering 75 days. A woman has her period in the first four days. Four weeks after the first day of that menstruation, her next period starts. She menstruates regularly and her menstruations always last for four days.

a Colour all the days on which the woman has her period red.

b Draw asterisks to mark the days on which this woman probably ovulates.

fig. 12



5

Summary

You can name the parts of the female reproductive system with their functions and characteristics.

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The menstrual cycle:

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INSIGHT

6 Lisa has ovulated regularly (every four weeks) from her 13th birthday onwards. Her menopause starts on about her 46th birthday and stops when she turns 51. Lisa has never been pregnant.

a Roughly how many ovulations will there have been in her body between her 13th and 46th birthdays? Include a calculation with your answer.

b Could Lisa still have had ovulations after her 46th birthday? Explain your answer.

c Can fertilization still take place in a woman's body (in normal circumstances) after the menopause? *yes* / *no*

7 Samuel says that the vagina of a girl who is still a virgin is entirely closed off by the hymen.

a Explain why menstruation shows that this is not true.

b Even doctors cannot tell whether a girl is still a virgin. Explain why.

8 Take a look at figure 4 and figure 11.

a Which part of the clitoris is most sensitive to stimuli?

- ○ A the clitoral glans
- ○ B the clitoral hood
- ○ C the erectile tissue

b What can these touches make happen?

c During sexual arousal, the inner labia may make mucus. This makes the entrance to the vagina moist and slippery.
What is the purpose of this?

+ 9 Read the text 'Man/woman/intersex?' in figure 13.
Hormones only have an effect in the tissues and organs that are sensitive to the specific hormone. While Caster Semenya was developing in the womb, testes were formed that secrete testosterone. That should have meant that she developed male sexual characteristics, but that did not happen. She developed to have a vagina rather than a penis and was deemed to be a girl and brought up as one.

a What led to Caster Semenya's tissues and organs developing into female genitals during development in the womb, although testosterone was being produced?

b During puberty, the pituitary gland secretes hormones that make the testes produce more hormones. Caster Semenya began to develop a lot of muscle mass and grew taller than the average woman. Those are male sexual characteristics.
Explain why.

c In the world of sports, athletes sometimes use anabolic steroids. Those are banned substances that simulate the effect of testosterone.
Explain why some female athletes use anabolic steroids.

d The testosterone level in Caster Semenya's blood is about three times higher than in the average woman. That is however still three times lower than for the average man. Do you think that Caster Semenya ought to have to take medicines to make her body produce less testosterone if she wants to keep competing in women's running races? Explain your answer.

fig. 13

Man/woman/intersex?
Hormones determine whether a person is male or female or develops some characteristics of both. The South African runner Caster Semenya (aged 28) produces a lot of the hormone testosterone. That is the hormone that makes you develop male physical characteristics. This means that she is taller and more muscular and stronger than women with lower testosterone levels. That helps Caster win a lot of races. Many people think that this is unfair and therefore think that she ought to take medicines to make her body produce less testosterone.

HOW IT FITS TOGETHER the living world

ENVIRONMENTALLY FRIENDLY MENSTRUATION

Many girls in Kenya do not have any money for sanitary pads and so they do not go to school for several days each month. Disposable pads and tampons are a blessing for women throughout the world. They are comfortable, hygienic and an important part of emancipation. Having periods causes a lot of waste too, as a result. Over the course of her fertile years, a woman uses about eleven thousand tampons or pads. It can take up to twenty-five years for some tampons or sanitary pads to be broken down. The ultra-absorbent granules in the pads and the plastic on the underside and the edges for preventing leaks are mostly not degradable. To put less of a burden on the environment, some women are switching to ecologically friendly products. The eco-cotton and bioplastics in these sanitary pads are biodegradable. Other environmentally friendly alternatives include washable sanitary pads and menstrual cups.

fig. 14 Washable sanitary pads.

10 Read the text 'Environmentally friendly menstruation'.

a Pads and tampons need to be changed regularly.
Give two reasons why.

b There is public debate about how environmentally friendly washable sanitary pads are.
Explain why not everybody thinks that washable pads are environmentally friendly.

c A menstrual cup lasts for years and does not create waste. Many women do not want them, though.
Have a look at figure 7.3 and try to think what the benefits and disadvantages are of using a menstrual cup. You could also discuss it with your classmates.

Go to the *Flash cards* and the *Test yourself* section.

3 A man

LEARNING OBJECTIVES

4.3.5 You can give the parts of the male reproductive system with their functions and characteristics.

4.3.6 You can give the characteristics of sperm cells and egg cells.

▶ Practical activities 1 and 2

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES		
	4.3.5	4.3.6	1.0.14**
Remembering	1, 2		
Understanding	4	3, 4	
Using	5, 10b	9ab	
Analysing	6ab, 7, 10acde	6a, 7, 8, 9c	10de

** You can find this learning objective in another unit.

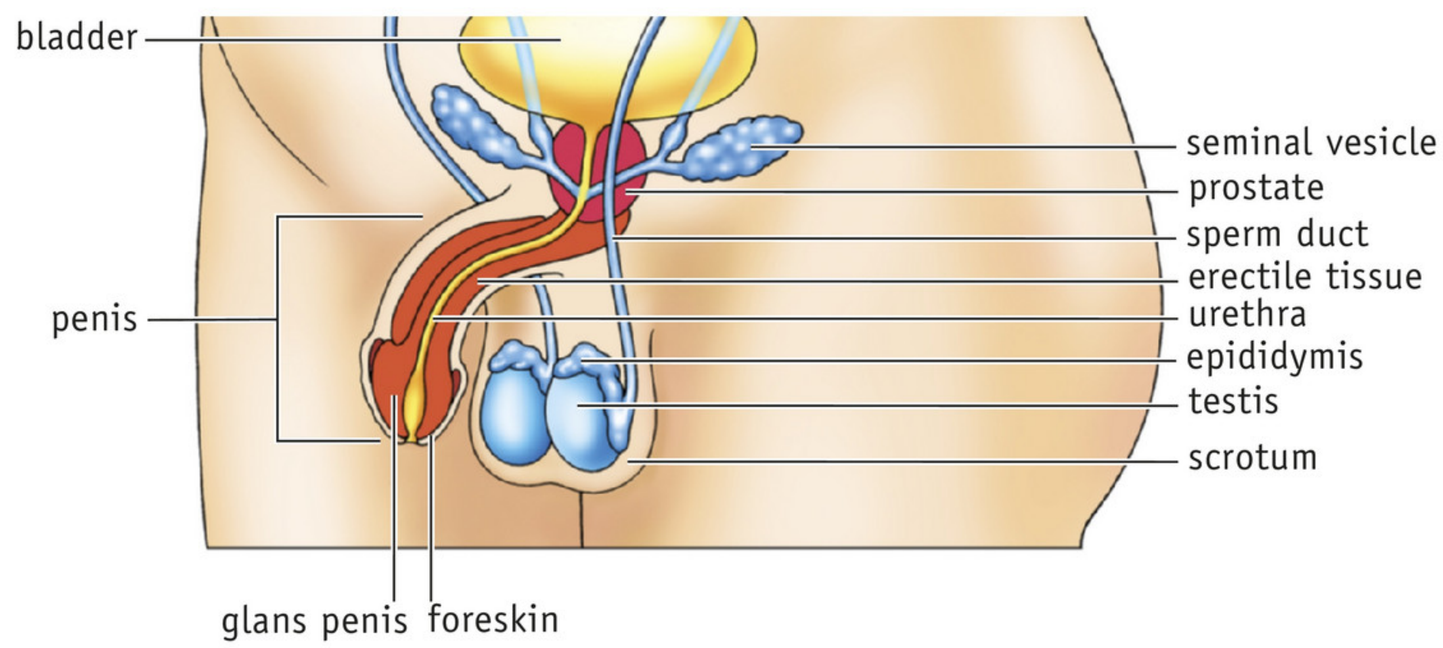
The male reproductive system is largely visible from the outside. Only the prostate gland and the seminal vesicles are inside, in the abdomen.

TESTES AND SCROTUM

Figure 1 is a photo of a naked man. You can see part of his reproductive system. The rest of his reproductive organs are in the lower abdomen (see figure 2).

fig. 1

fig. 2 The male reproductive system (schematic).



When a boy is aged about 13, his **testes** start to function. From that age onwards, the testes produce many millions of **sperm cells** every day. Sperm cells are the male sex cells. The testes are located in a fold of skin called the **scrotum**. The temperature in the scrotum is slightly lower than in the abdominal cavity, which is favourable for the development of sperm cells.

As in girls, hormones play an important role in the formation of sex cells in boys. At the start of puberty, the pituitary gland starts making stimulatory hormones. Under the influence of those hormones, a boy or man produces sperm cells in the testes. In a man, the pituitary gland keeps producing these stimulatory hormones through to an advanced age. Sperm cells can therefore also be produced until an advanced age. So men do not go through the menopause like women do.

PROSTATE GLAND AND PENIS

The sperm cells are stored temporarily in the **epididymis**. The **sperm ducts** transport the sperm cells.
The **seminal vesicles** and the **prostate** add fluid to the sperm cells. The fluid from the seminal vesicles contains nutrients for the sperm cells. The fluid from the seminal vesicles and the prostate gland plus the sperm cells are collectively referred to as **semen**.
At the prostate gland, the sperm ducts exit into the urethra. The urethra goes through the **penis**. The end of the penis (the head or **glans penis**) is very sensitive. The head of the penis is covered by a thin fold of skin called the **foreskin**. It protects the glans penis (the head of the penis). The foreskin is large enough that it can be retracted back over the head of the penis. To avoid inflammation or infection, it is important that a boy pulls the foreskin back when showering so that the glans penis and foreskin can be rinsed.
Some boys have their foreskin cut away; this is called circumcision. Sometimes it is done for hygienic reasons and sometimes for religious reasons, for example by Jews and Muslims.

The penis mostly hangs loosely or 'flaccid', but it can also become larger and stiff. This is referred to as an **erection**, or by other terms such as a 'hard-on'. An erection is caused by the **erectile tissue** in the penis (see figures 3 and 4). There is erectile tissue on the underside around the urethra. There is also erectile tissue on the upper side on the left and on the right. The erectile tissue can become filled with blood, making it larger and firmer. The penis then becomes erect (see figure 4). The size and shape of the flaccid penis can vary quite a lot between men. But there is not so much difference between erect penises. Boys and men can get erections at the most inconvenient moments. For example during examination by a doctor, a bit of rough-and-tumble, or when dancing close. Boys and men often get erections at night or when they wake up.

EJACULATION

The man can use the erect penis to place sperm cells inside the body of a woman. This is done during **sexual intercourse** ('fucking'). In sexual intercourse, a man inserts his erect penis into a woman's vagina. The movements of the man and woman move the penis back and forth inside the vagina. This stimulates the head of the penis continuously. The result is that the man may have an **ejaculation**. In an ejaculation, the semen comes out via the urethra in spurts. The semen then ends up in the woman's vagina.
About a teaspoonful of semen comes out of the penis in each ejaculation. Semen is sticky and milky white. A single ejaculation contains 100 to 400 million sperm cells.

fig. 3

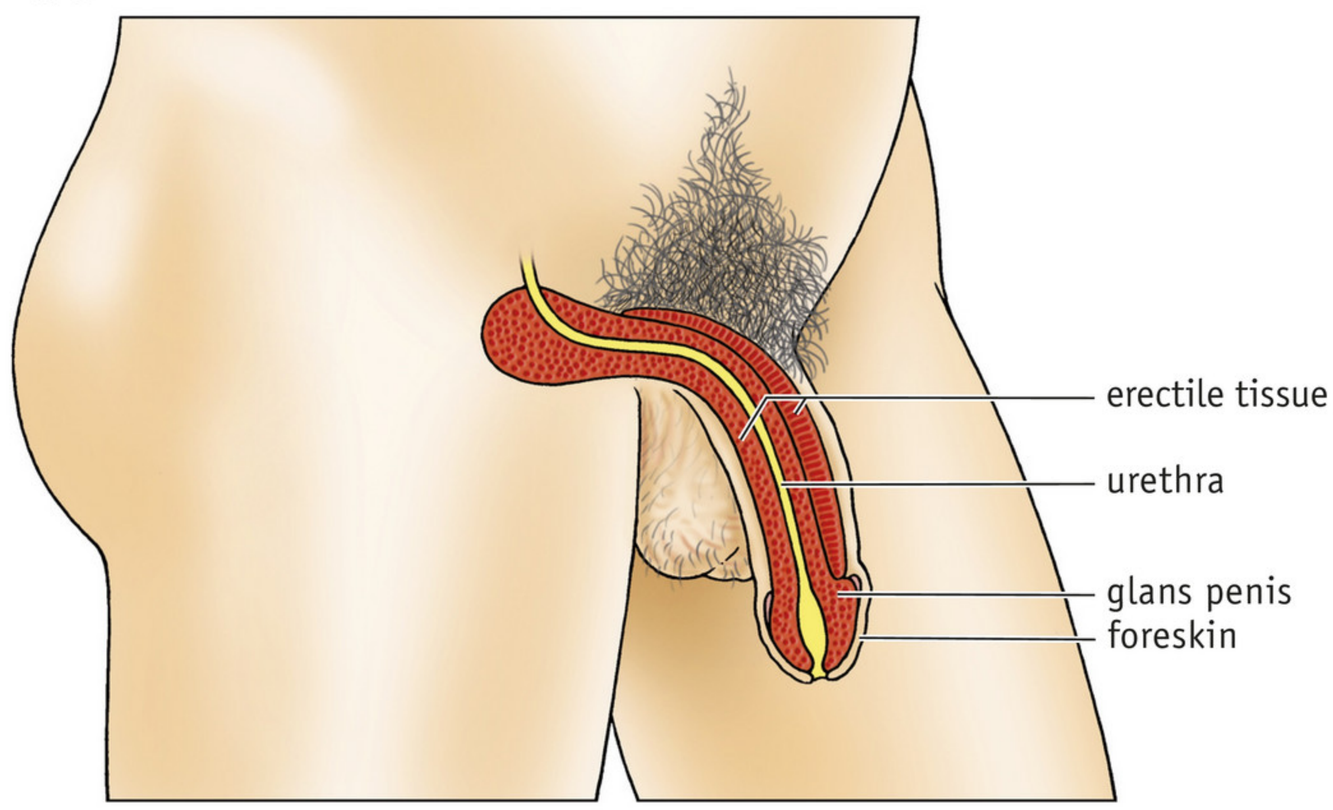
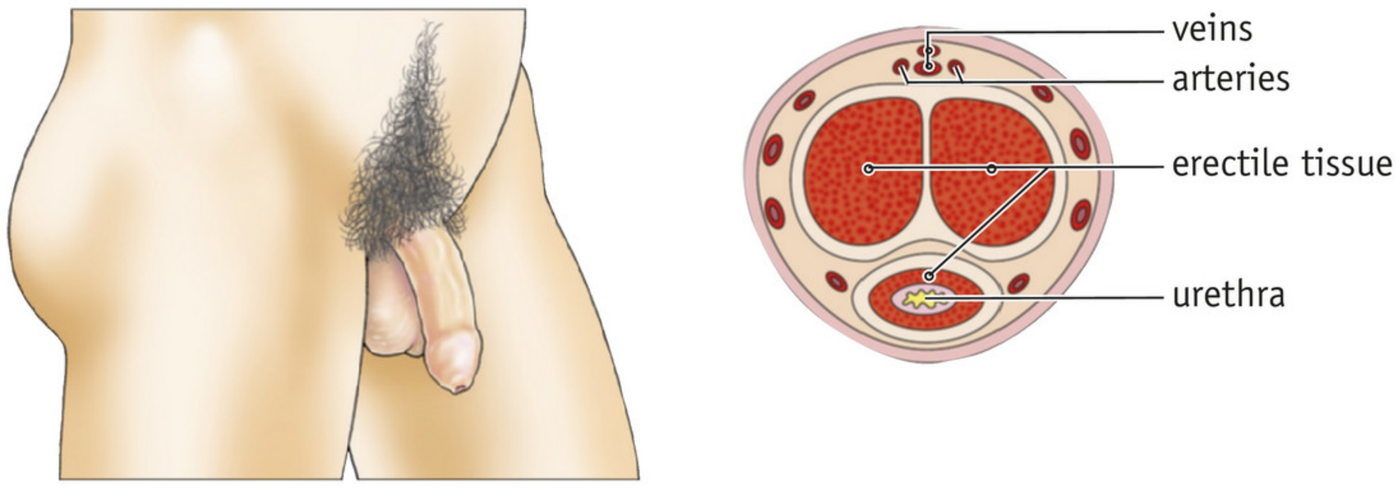
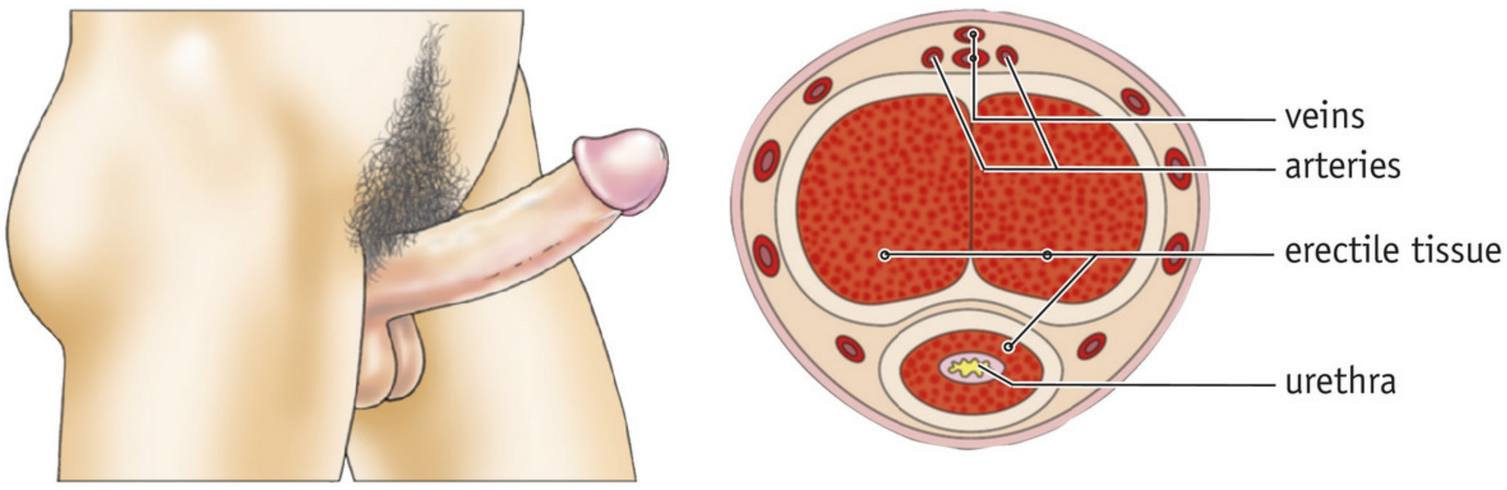


fig. 4 The penis (external view and cross-section).



1 in the normal state (flaccid)



2 erect

Sometimes an ejaculation can occur spontaneously at night when the man or boy is asleep. This is called a 'wet dream'. On average, a boy's first ejaculation will be when he is aged about 13. Some boys have ejaculations at age 11, and others do not have their first ejaculation until they are 18.

SPERM CELLS AND EGG CELLS

A sperm cell is the smallest type of human cell (see figure 5). It has a tail called a **flagellum** that allows the sperm cell to move. That allows the sperm cells to 'swim' into the womb and the Fallopian tubes after an ejaculation. If they meet an egg cell in the Fallopian tube, they can fertilize it (see figure 6). The egg cell cannot move autonomously. An egg cell can only be fertilized immediately after ovulation (up to 24 hours afterwards).

fig. 5 Electron microscope photo of sperm cells (1260× magnification).

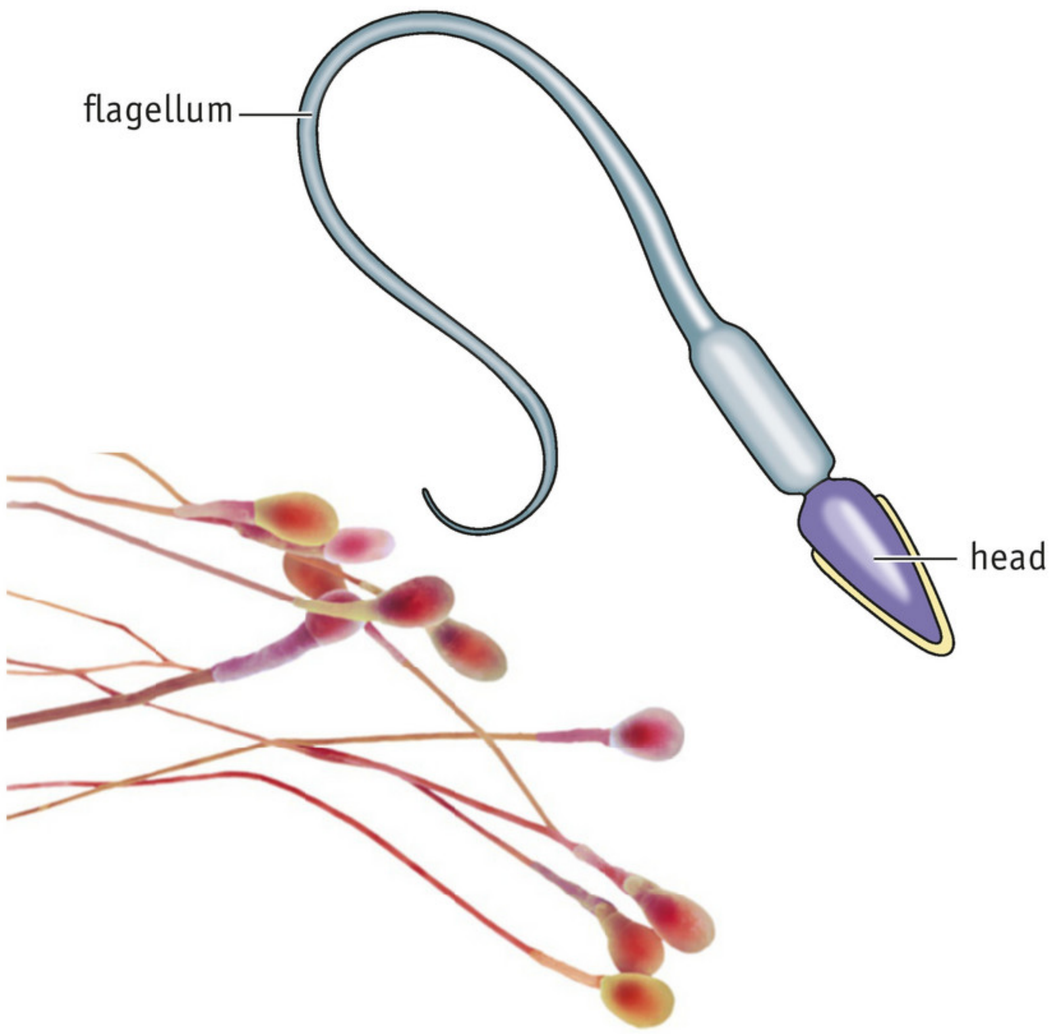
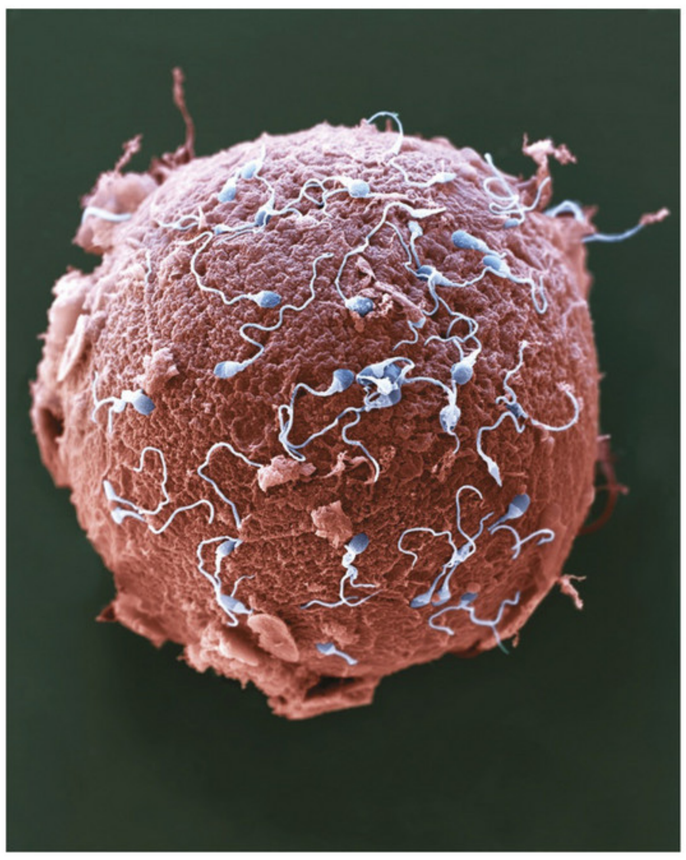


fig. 6 An egg cell with sperm cells (360× magnification).



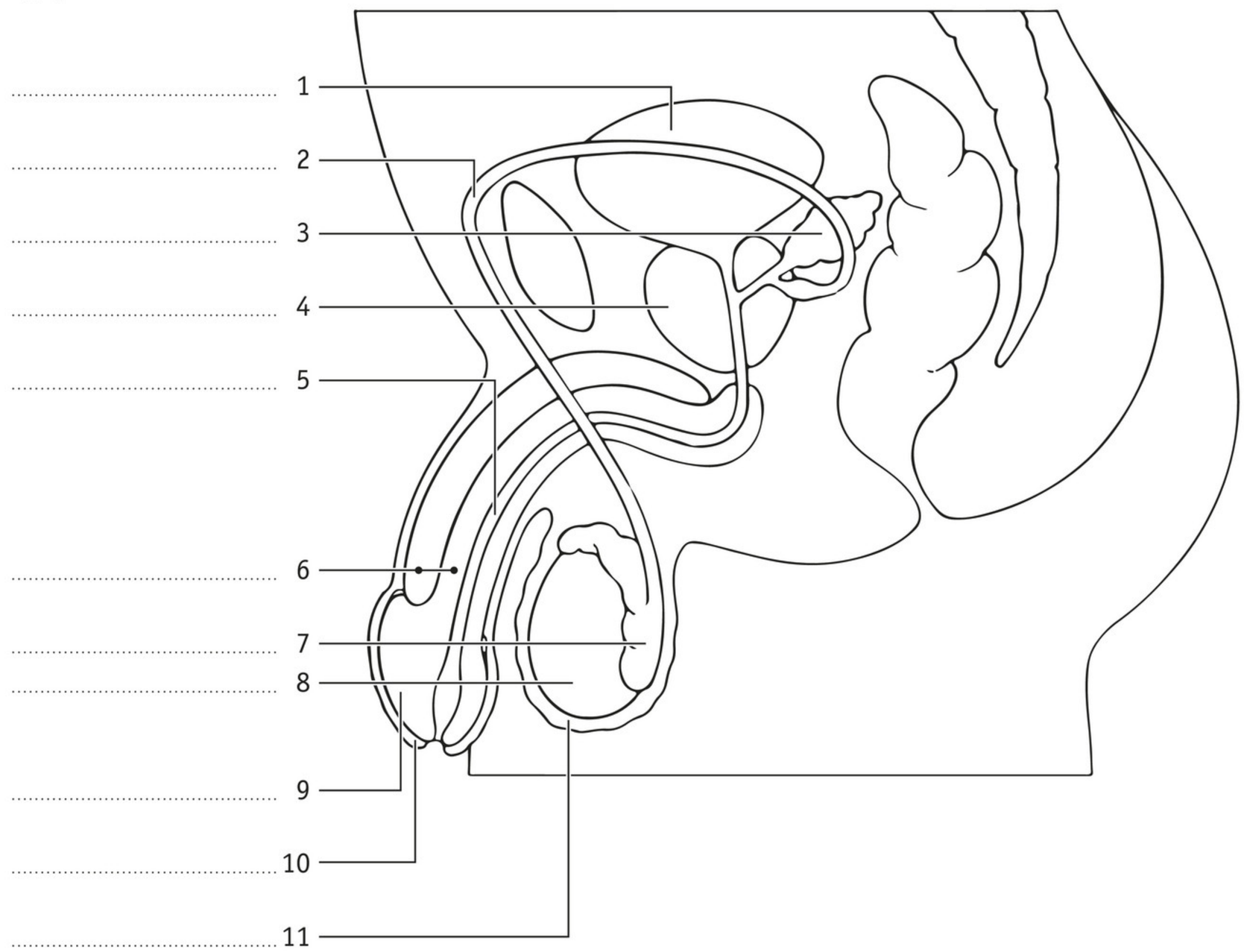
KNOWLEDGE

1 Figure 7 shows you a drawing of the male reproductive system.

a Write down the names of the numbered parts.

b Colour in the various parts in the drawing. Use a different colour for each part.

fig. 7



2 Which part of the male reproductive system belongs with each function?

A	Inserts semen in the vagina.	○	○ 1 scrotum
B	Parts that make the penis become erect.	○	○ 2 epididymides
C	It contains the testes and epididymides.	○	○ 3 glans penis
D	Goes through the penis and transports urine and semen.	○	○ 4 penis
E	Store sperm cells temporarily.	○	○ 5 urethra
F	Sensitive to stimuli that could result in an orgasm.	○	○ 6 seminal vesicles
G	Transport sperm cells.	○	○ 7 sperm ducts
H	Adds fluid with nutrients for the sperm cells.	○	○ 8 erectile tissue

3 Choose the correct sex cells.

- they are bigger *egg cells / sperm cells*
- they can move autonomously *egg cells / sperm cells*
- they have food reserves *egg cells / sperm cells*
- they are produced in larger quantities *egg cells / sperm cells*

4 **Summary**

The parts of the male reproductive system with their functions and characteristics are:

.....

.....

.....

.....

.....

.....

.....

.....

.....

Sexual intercourse:

.....

.....

Characteristics of sperm cells and egg cells:

Sperm cells: .....

.....

Egg cells: .....

.....

INSIGHT

5 After sexual intercourse, a sperm cell can fertilize an egg cell.
Which parts of the male and female reproductive organs does the sperm cell pass through before reaching the egg cell? Put the parts in the right order.

..... womb

..... epididymis

..... Fallopian tube

..... testis

..... urethra

..... vagina

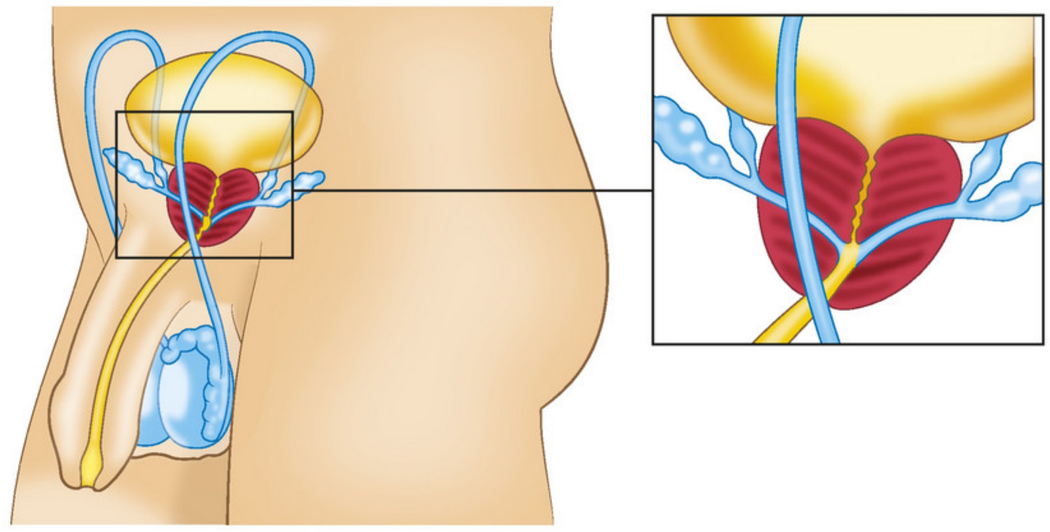
..... sperm duct

6 The prostate gland produces a fluid that makes the acid environment in the vagina less acidic. That helps the sperm cells to survive for longer.

a Why is it important for the sperm cells to survive for as long as possible?

b Men aged over 50 in particular can suffer from an enlarged prostate gland (see figure 8).
Explain how this can cause problems urinating.

fig. 8 Enlarged prostate gland.



7 If an inflammation blocks the exit ducts from the seminal vesicles, the production of semen decreases by 70%.

a Put the components of semen in the correct sequence in terms of volume. Start with the component that there is most of in the semen.

..... fluid from the prostate gland

..... fluid from the seminal vesicles

..... sperm cells

b The fluid that the seminal vesicles add to the sperm cells contains fructose. This is a nutrient that is rich in energy.
Explain why the sperm cells need external nutrients during their journey while egg cells do not.

8 Read the text 'Sexual or asexual reproduction' in figure 9.

a Write down two advantages of asexual reproduction.

b Organisms need to be able to produce egg cells or sperm cells for sexual reproduction.
How can you tell from the structure of an organism whether it can produce egg cells or sperm cells?

fig. 9

Sexual or asexual reproduction

Organisms can reproduce sexually or asexually. In asexual reproduction, part of an organism can grow into a new individual. This happens when you plant a cutting, or when the arm of a starfish grows into a new starfish (see the photo). In sexual reproduction, an egg cell from an organism has to be fertilized by a sperm cell from an organism of the same species.

+ 9 Read the text 'Competing semen in dragonflies' in figure 10.

a The male dragonfly tries to remove the semen of the previous male.
What consequence does this have for the hereditary characteristics of the offspring?

b After mating, the female dragonfly stores the semen, so its eggs can be fertilized with the semen of multiple males.
What consequence does this have for the hereditary characteristics of the offspring?

c What advantage does this have for the species? Hint: think about variation and selection.

fig. 10

Competing semen in dragonflies

Female dragonflies are not very romantic: they mate with multiple males. During mating, the male first tries to remove the semen of the previous male so that the egg cell is fertilized by its own semen. They have a special brush-like organ on the penis for this. But the female has storage spaces hidden away for the semen so that it can keep some semen from all the males it mates with.

HOW IT FITS TOGETHER science

ROOMY UNDERPANTS

A lot of research has been done on how the kind of underpants affects the quality of men's semen. Now American researchers have carried out a new study. 656 men aged between 18 and 56 were asked what kind of underpants they had worn most in the past three months. Semen samples were also taken. The semen samples were tested for the total volume, the concentration of sperm cells (amount per millilitre) and the mobility of the sperm cells (see table 1). The temperature of the scrotum was not measured directly.

55% of the men generally wore boxer shorts. This group was younger and thinner on average and took a hot bath or bubble bath more often.

Source: 'Type of underwear worn and markers of testicular function among men attending a fertility center', Lidia Mínguez-Alarcón, Human Reproduction (vol. 33, no. 9), 2018.

fig. 11

Table 1

Type of underpants	Ejaculation volume (mL)	Concentration of sperm cells (million/mL)	Mobility of sperm cells (%)
Roomy (boxer shorts)	3.03	64.7	49.3
Tight	3.05	51.9	46.4

10 Read the text 'Roomy underpants'.

The research question shows that the scientists suspected that choosing tight underwear might have a negative effect on the quality of a man's semen.

a Explain why they suspected this.

b What conclusion can you draw from the results?

c All the men in the study were men who had come to a fertility centre with their partner. These men were given a questionnaire to take home. 656 of the men completed the questionnaire.
Explain why this makes the study less reliable.

d The men had to say themselves whether they wear roomy or tight underpants.
Explain why this makes the study less reliable.

e The men who generally wore boxer shorts were younger and thinner on average and took a hot bath or bubble bath more often.
Explain why you can't conclude that men who wear roomy underpants are more fertile from the results of this study.

Go to the *Flash cards* and the *Test yourself* section.

4 Sex and all that

LEARNING OBJECTIVES

4.4.7 You can describe what sexuality means.
4.4.8 You can say how gender and sexual orientation can differ.
4.4.9 You can say how wishes and limits can be set and respected in a sexual relationship.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES		
	4.4.7	4.4.8	4.4.9
Remembering	1abde		3ac
Understanding	1c, 4	2, 4	3b, 4
Using	5d	5a, 6	7, 8, 10acde
Analysing	5bce	9	10b

From puberty, sexuality will start to play a role in your life. Sexuality is also important in the lives of adults. People can have very different opinions about it.

ORGASM

The glans of the penis and of the clitoris are very sensitive to stimuli. Stimulation of the glans, for example during sexual intercourse, can give someone an **orgasm** (make them '**come**'). In men, an ejaculation then occurs. In women, the muscles around the vagina tense. An orgasm gives a pleasant sensation.

You can also give yourself an orgasm. Rubbing the penis or clitoris can give you a pleasant sensation. This is called **masturbation**. A boy can get an orgasm by moving the skin of the penis back and forth by hand; terms for this include 'wanking' and 'jerking off'. A girl can rub the clitoris, with or without fingers in the vagina. Again, there are other terms for it such as "fingering yourself". Many boys and girls pleasure themselves this way, but there is nothing unusual about it if you do not want to.

SEXUALITY

Sexual intercourse and masturbation are part and parcel of sexuality. The term **sexuality** covers all thoughts, feelings and actions that are related to lust and arousal. Sexuality can have various functions for people: libido, intimacy and reproduction.

Sexuality can give people a great deal of pleasure. Being sexually aroused is a pleasant feeling. This is referred to as **libido**. People can become sexually aroused by all kinds of stimuli, such as touching, stroking, kissing and foreplay. Simply looking at someone you find attractive can be enough to cause sexual arousal.

Sexuality can play a role in **intimacy** or in keeping a loving relationship going with someone (see figure 1). If you love someone in this way, you will want to make it clear to them regularly, for instance by stroking or cuddling them. If you love someone, you may want to make love or have sexual intercourse with them. That can create a bond between you.

fig. 1 Intimacy in a loving relationship.

A man and a woman can have sexual intercourse. If a sperm cell from the man fertilizes an egg cell from the woman, she may become pregnant. So sexuality plays a role in **reproduction**. Many people have sexual intercourse without wanting a child. To prevent pregnancy, they use **contraceptives** such as a condom or the pill.

Photos, films and text aimed at stimulating people sexually are called **pornography** ('**porn**'). This often involves clear pictures (or descriptions) of the sex organs. They often don't look like most people's do in reality. The actors don't behave naturally either. If you watch a lot of porn, you can get an unrealistic picture of sexuality. In reality, it is not like that. So you can't use pornography to learn more about sexuality.

SEXUAL ORIENTATION

Your sexual orientation or sexual preference is about who you fall in love with (see figure 2). The majority of people feel sexually attracted to people of the other sex. These people are **heterosexual** (*hetero* = not the same). About one in fifteen people are **homosexual** (homo = the same) or bisexual (bi = two). Homosexual people feel attracted to other people of the same sex. Girls and women who are homosexual are also called **lesbians**. People who feel attracted to both men and women are called **bisexual**. Some people feel no sexual attraction to other people. They are called **asexual**. For some people, the other person's sex or gender doesn't matter. They are called **pansexual**.

fig. 2

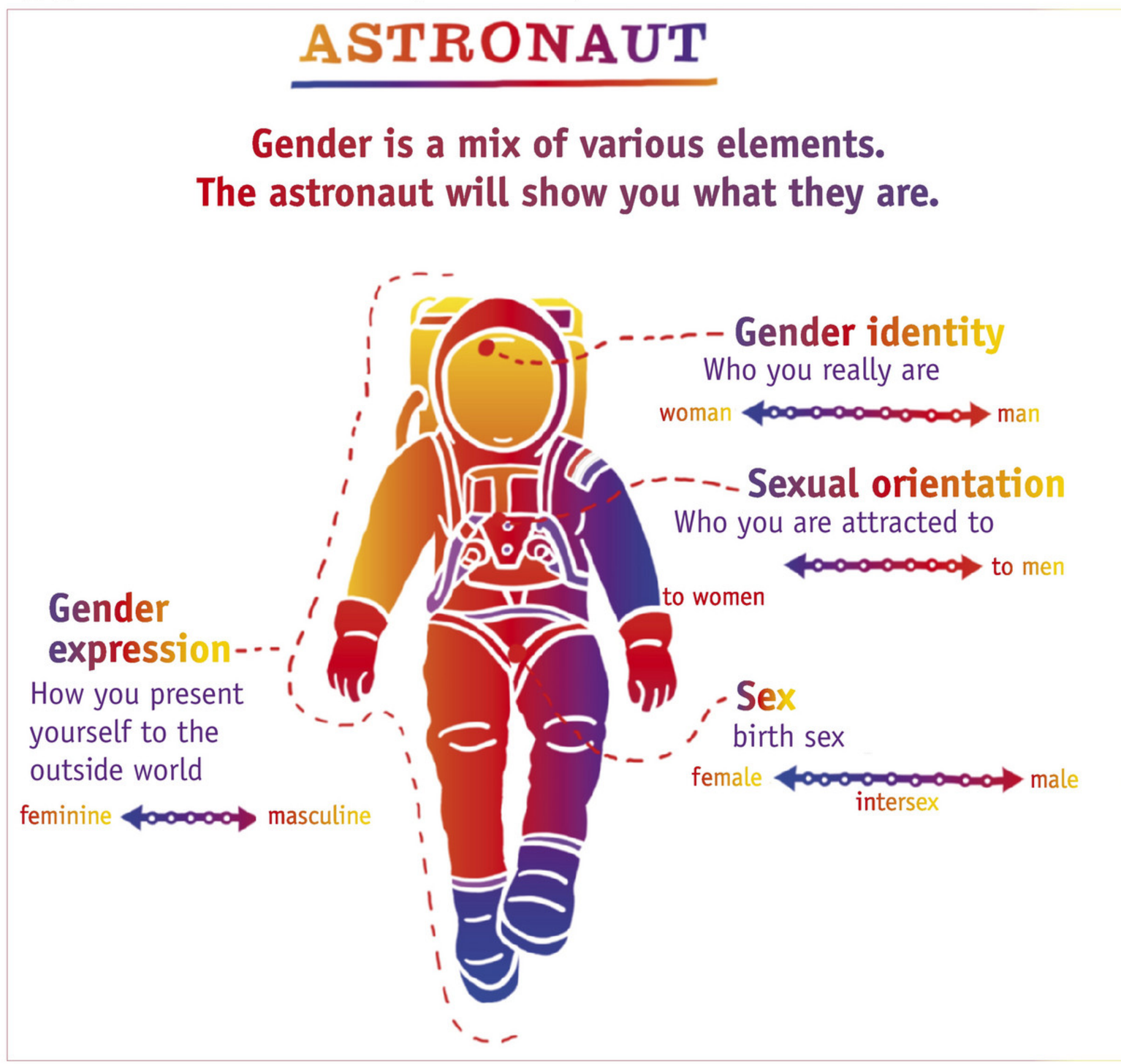
SEX AND GENDER

When it comes to sex and sexuality, you will often see the abbreviation LGBTI (sometimes with more letters at the end). The letters stand for **l**esbian, **h**omosexual, **b**isexual, **t**ransgender and **i**ntersex. This list covers sexual orientations but also includes terms that have nothing to do with sexuality, namely 'transgender' and 'intersex'. Those terms are about gender and sex.

A person's **sex** (male, female or intersex) is about their physical sexual characteristics, such as the penis or vulva. **Gender** refers to the characteristics and behaviours that people think are masculine or feminine. Some examples are playing with dolls or cars, wearing trousers or a dress, being tough or caring.
Your gender is made up of your sex, your identity (who you are, how you feel inside) and your expression of yourself (how you dress and behave). Figure 3 shows this. Your sexual orientation says nothing about your gender but it does say something about the gender you fall for.

In **transgender** people, the gender identity (their feeling) doesn't match their sex (their body). If someone feels uncomfortable with their gender, that is called **gender dysphoria**. Some transgender people choose to have operations to change their sex so that their body (sex) matches their gender identity.
A **transsexual** person is a man in the body of a woman or the other way around. So transsexuality is an extreme form of transgender. People who are transsexual usually have medical treatment to change their sex. Then the body (sex) matches the gender identity.

fig. 3 Gender is the sum of many different aspects.



Source: www.gsanetwerk.nl.

A SEXUAL RELATIONSHIP

You often fall in love for the first time in puberty. You think about that person all the time and want to be close to them. If you see them, you get a deep, intense feeling. You also really want that other person to like you. Perhaps you want them to touch you or kiss you. If you are in love, you probably want to do something about it. Figure 4 gives you some tips for showing someone else that you really like them.

fig. 4

Eight tips for flirting

1 Make eye contact.
2 Make sure you 'happen' to be close to them.
3 Start chatting and show you are interested.
4 Smile (although you will probably do that automatically).
5 Give them compliments.
6 Touch the other person 'accidentally'. But note: no sexual harassment.
7 Get to know the other person better by chatting online.
8 Ask a friend to find out whether the feeling is mutual.

Source: Lang Leve de Liefde magazine.

If you are dating, you may kiss, hold hands or touch one another. It is important to know what the other person wants and what they don't want. Perhaps you have the same ideas about kissing and sex. Talk about that with one another. Ask each other questions. Tell the other person things about yourself. If you don't want to do something (or not yet), there is nothing wrong with that. Neither is it weird if you do want to do something. You explore sexuality and relationships together at your own pace. Don't do anything you don't want to or that the other person doesn't want to. That keeps it a nice experience for both of you.

A healthy relationship is mutual (you both want it) and equal (not one partner controlling everything). You should also respect and trust one another.

WISHES AND BOUNDARIES

In a sexual relationship, there are things you hope will happen. They are your **wishes**. There are also things you don't want or feel uncomfortable with. These are your **boundaries** or **limits**. Wishes and boundaries are very personal. Some people think kissing with tongues (French kissing) is fantastic and others think it is yucky. Many young people are not yet sure about their wishes and limits. You discover your wishes and boundaries in your first sexual relationships.

Sometimes you will notice you don't like something while you are doing it. You feel uncertain, agitated or uncomfortable with it. That means you have discovered a boundary. If you feel you have reached a boundary, take that feeling seriously. Tell the other person how you feel. If you go further than you want deep down inside, you will regret it later. Tell your partner what your boundary is, and stop what you were doing. If you think you feel reluctance but you aren't sure, ask the other person whether they are still happy doing this. Look out for signs, such as avoiding your eyes or turning away. Figure 5 gives more tips on wishes and boundaries.

fig. 5

Respecting wishes and boundaries

- Talk to each other about you do and don't want.
- Show non-verbally what you do and don't want, for example by guiding the other person's hand.
- Say clearly when you don't want to do something: "I don't feel comfortable with this, I don't want to do it."
- And say what the other person should then do: "I want you to stop that."
- If the other person does not respect your boundaries, they are not worth being with.

UNDESIRABLE BEHAVIOUR

A boy who touches you on the dance floor. A girl who shows everyone a sexy photo of you. Your boyfriend or girlfriend who wants to have sex with you when you don't want it. These are examples **unacceptable sexual behaviour**: someone makes sexual comments or performs sexual acts that you don't want. Such behaviour is not OK. You should say something about it, and report it if the person won't listen to you. Boundaries differ between people. Something you are fine with can cross someone else's boundaries.

In the case of **sexual harassment**, someone touches you when you don't want them to. It is also possible that someone may force you into sexual contacts. This is called **sexual violence**. The victim suffers sexual abuse. An **assault** refers to sexual activities performed with the victim involving violence or threats. **Rape** involves sexual intercourse as well. An assault or rape by a member of your family is called **incest**. Sexual violence is forbidden by law and can result in prison sentences for the perpetrators.
Sexual violence can also take place via the Internet or a chat app (see figure 6). For example, a girl who forces a boy to show his penis on the webcam, or a girl's ex-boyfriend who threatens to share nude photos of her if she doesn't do what he wants.

fig. 6 Sexual violence can also take place via the Internet or a chat app.

A '**loverboy**' is someone who starts by 'grooming' a girl – being very nice to her and tempting her with attention and expensive gifts. 'Loverboy' is the Dutch term for a young man who makes sure that the girlfriend has no other contacts except with him. That gives him power over her. Eventually, he wants something in return for his 'love'. He forces the girl into prostitution to earn a lot of money. If you think the boyfriend of one of your female friends is grooming them like that, look for help. Talk to someone you trust, such as your parents or a teacher.

Victims of sexual violence often suffer from emotional or physical problems. It is important to look for help rather than try and carry on as if nothing happened.

Figure 7 lists websites where you can read more about sexuality.

fig. 7

Websites about sexuality (in Dutch)

About sex and sexuality
www.sense.info
www.canyoufixit.nl

About gender, sex and sexual orientat
www.gsanetwerk.nl
www.iedereenisanders.nl
www.coc.nl
www.colourground.nl
www.seksediversiteit.nl

For help after sexual violence
www.kindertelefoon.nl
www.centrumseksueelgeweld.nl
www.stoploverboys.nu
www.verbreekdestilte.nl

KNOWLEDGE

1 Sexuality has various functions.

a What is sexuality?

b Which descriptions belongs with which functions?

A	sexual intercourse, pregnancy	○	○ 1 intimacy
B	feeling close to one another in a romantic relationship	○	○ 2 libido
C	arousal, lust, pleasure	○	○ 3 reproduction

c Masturbation *is* / *is not* sex.

d In both men and women, the stimulation of one part of the reproductive system can lead to an orgasm.
Which part of the reproductive system is that?

e Pornography is aimed at arousing people sexually.
What disadvantage does pornography have?

2 Eight terms about sexual orientation and gender are given below.
Which description belongs with each term?

A	asexual	○	○ 1 the person's gender does not match how they feel
B	bisexual	○	○ 2 whether someone feels masculine, feminine or something in between
C	gender identity	○	○ 3 attracted to people regardless of their gender
D	heterosexual	○	○ 4 attracted to people of either sex
E	homosexual	○	○ 5 attracted to people of the opposite sex
F	pansexual	○	○ 6 attracted to people of the same sex
G	transgender	○	○ 7 feels no sexual attraction

3

a When you have reached a boundary in a sexual relationship?

b Which of these are true in a healthy sexual relationship?

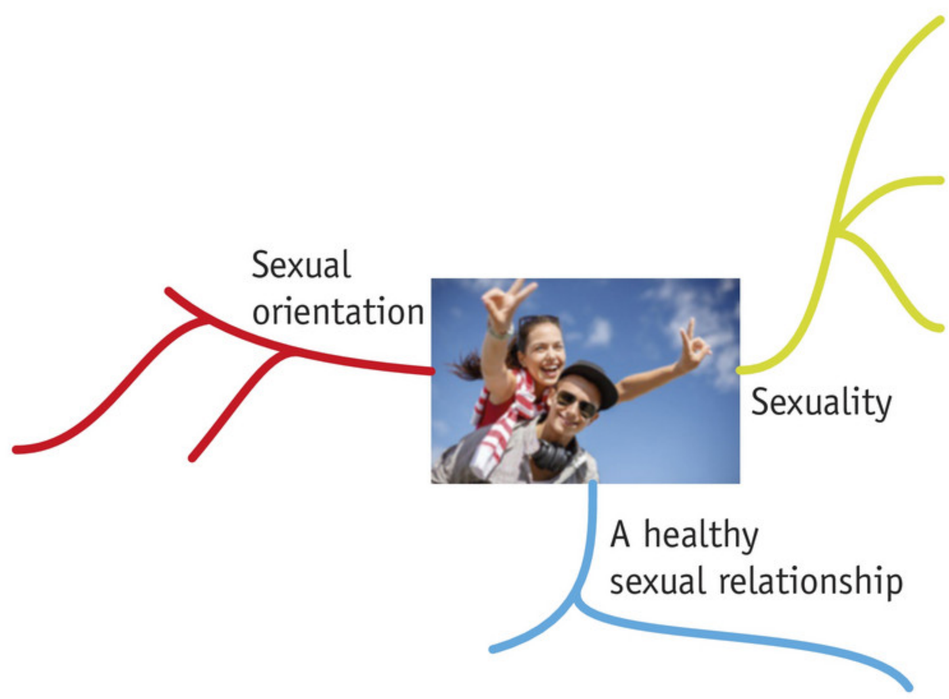
- ☐ A There is one person who is in control.
- ☐ B You occasionally do things you are not comfortable with.
- ☐ C You respect one another.
- ☐ D You trust one another.

c In unacceptable sexual behaviour, someone may touch you when you don't want them to.
What is this behaviour called?

4

Summary
Figure 8 is the start of a mind map.
Finish the mind map.

fig. 8



INSIGHT

5

a What were the main aspects you learned about regarding puberty, women and men in basics 1, 2 and 3?

- ○ A gender expression
- ○ B gender identity
- ○ C sex
- ○ D sexual orientation

b There are many different cultures in the world and they can have very different sexual norms and values.
One website states: "The reproduction viewpoint dominates in most Western cultures."
What do you think is meant by this statement?

c Dating and marriage are ways in which two people can have a relationship with one another. The choice of a particular kind of relationship must fit with the couple's norms and values.
Write down three different attitudes people might have about relationships and sexual intercourse.

d Sometimes, a young boy who is playing with his penis is told to stop it because that is 'dirty'.
What function of sexuality is being rejected here?
○ A intimacy
○ B libido
○ C reproduction

e These days you can put on virtual reality goggles and experience porn as if you are really having sex. Eventually it will be possible for every adult with an Internet connection to have sex with really good looking digital models.
What might be a disadvantage of virtual-reality porn?

6

In this exercise, you will see that terms for sex, gender and sexual orientation are not always clear-cut. So it is not about giving the 'correct' answer.
Discuss each question with two classmates. Remember that everyone is different and should be able to be themselves without shame or having to defend or justify it.

a Look at figure 9.1. Jett Rebel is a Dutch singer and composer who plays lots of instruments. Jett Rebel says he thinks it is 'short-sighted' of him not to be bisexual and only to be attracted to women.
What do you think applies to Jett Rebel?
Sex: *male* / *female* / *intersex*
Sexual orientation: is attracted to *men* / *people in general* / *women* / *asexual*
Gender expression: *masculine* / *neutral* / *feminine*
Gender identity: *male* / *neutral* / *female*

b Look at figure 9.2. Marieke Lucas Rijneveld (born Marieke Rijneveld) is a Dutch author and poet. They (Rijneveld has deliberately chosen to use 'they' in English) are often a guest on TV programmes. They are not sure whether they want to be a girl or a boy but they mainly still feel that they are a child.
What do you think applies to Marieke Lucas Rijneveld?
Sex: *male* / *female* / *intersex*
Sexual orientation: is attracted to *men* / *people in general* / *women* / *asexual*
Gender expression: *masculine* / *neutral* / *feminine*
Gender identity: *male* / *neutral* / *female*

fig. 9

1 Jett Rebel

2 Marieke Lucas Rijneveld

c Look at figure 9.3. Brendon Urie is the lead singer of the band Panic! at the Disco. In an interview, the singer said he doesn't care about gender: "I'm married to a woman but I'm not opposed to a man because I like a person. I'm definitely attracted to men sexually. It has never been weird for me."
What do you think applies to Brendon Urie?
Sex: *male* / *female* / *intersex*
Sexual orientation: is attracted to *men* / *people in general* / *women* / *asexual*
Gender expression: *masculine* / *neutral* / *feminine*
Gender identity: *male* / *neutral* / *female*

d Look at figure 9.4. Caitlyn Jenner was born male but feels like a woman. She has been legally a woman since 2015. She is in a relationship with a younger woman.
What do you think applies to Caitlyn Jenner?
Sex: *male* / *female* / *intersex*
Sexual orientation: is attracted to *men* / *people in general* / *women* / *asexual*
Gender expression: *masculine* / *neutral* / *feminine*
Gender identity: *male* / *neutral* / *female*

fig. 9

3 Brendon Urie

4 Caitlyn Jenner

7

The table gives various statements.

- Write down whether you agree or disagree with each statement.
- Then compare your answers with the answers of three classmates and discuss the reasons for the similarities and differences.

Statement	Agree	Disagree
If a boy takes a girl back to her home, he can expect a reward.		
A girl who dresses provocatively is asking to be raped or assaulted.		
If your boss keeps putting his arm around your shoulder, you should let him do that.		
It's OK for a girl to flirt with a boy.		
The most important thing in sex is that you personally enjoy it.		
If you are a girl, it is best not to cycle along the streets at night on your own.		
You can recognize a loverboy immediately from his grooming behaviour.		

8 Anyone can be the victim of a sexual assault or rape. If you have suffered a sexual assault or rape, you can contact the Sexual Assault Center (Centrum Seksueel Geweld). Doctors, nurses, police and other professionals work together to give you the right care.

a What care can a doctor give you after a sexual assault or rape?
b What care can a psychologist give?
c What care can the police give you?

+ 9 Read the text 'Homosexuality in animals' in figure 10.
The Laysan albatross has a shortage of male birds. The birds solve this problem by forming pairs of two females rather than heterosexual pairs. This means they are not fighting for males and the young have a better chance of survival.

a Are these females homosexual? Explain your answer.
b In elephants, the female is fertile for a period of about six days once every three years. She only wants to mate during that short period. The male needs to respond quickly, but he also needs to know how to have sex for the mating to be successful. What advantage does homosexuality among male elephants have?
c In black swans and flamingos, the males are larger and stronger than the females. Pairs of male birds steal an egg from the nest of a heterosexual pair and then sit on the egg until it hatches. Chicks that are raised by a pair of male birds have a much higher chance of survival.
How can that be explained?
d What disadvantage does homosexuality have for animals?

fig. 10

Homosexuality in animals
It has been known for some time that homosexuality occurs regularly in the animal kingdom. There are apes and albatrosses who spend their entire lives with a partner of the same sex. Denver Zoo has two homosexual flamingos that have been together since 2014. They have even built a nest and are waiting for an egg to adopt.

HOW IT FITS TOGETHER the living world

SEXTING CROSSES BOUNDARIES

Sexting is a combination of the words 'sex' and 'texting' (sending text messages). Sexting means sending and receiving sexual photos, videos or text messages on social media using a smartphone or a computer. Having 'virtual sex', for example via Skype, is also a form of sexting.
One in five young people sometimes send sexual photos to someone else. That can be fun and exciting but it is also risky. Once a sexy photo or video of you starts circulating on social media, you lose control over it. That can have huge consequences. It can lead to bullying (including cyberbullying), dropping out of school, shame, blackmail, problems finding a job, anxiety, insecurity and other forms of intense personal suffering. In some cases it has even led to suicide.

fig. 11

10 Read the text 'Sexting crosses boundaries'.

a People who spread sexy photos or videos without permission are committing a criminal act.
What do you call their behaviour?

b The police advise young people never to send sexy photos or videos. Then there are no photos or videos that can be circulated and the rest of the world won't judge you. Why do many people think this is not good advice? Discuss your answer with your classmates.

c A 14-year-old boy and a 15-year-old girl were prosecuted for sexting. They had circulated a nude photo of a 14-year-old boy, who committed suicide from shame by jumping off a block of flats. The victim had begged them to stop spreading the photo but the next day the boy and girl decided to post the photo on Instagram and tag the victim in the post.
Do you think it is right for this boy and girl to be prosecuted for sexting? Explain your answer. Discuss your answer with your classmates.

d The police investigation showed that the boy who was prosecuted had made a Snapchat account under a false girl's name (Alicia). He had contacted the victim through that account and swapped photos. The victim sent a nude photo of himself with an erection in which he is completely recognizable.
Does this information change your answer to Question (c)? Explain your answer. Discuss your answer with your classmates.

e The makers of a TV programme for young people think there is nothing wrong with sending photos via social media that other people find arousing. But it should be safe: the photos should not show your face. The campaign #geen hoofd (#noface) aims to reduce the negative consequences of sexting.
What do you think of safe sexting? Explain your opinion. Discuss your opinion with your classmates.

Go to the *Flash cards* and the *Test yourself* section.

5 Safe sex

LEARNING OBJECTIVES

4.5.10 You can list some methods for contraception and explain how they work.

4.5.11 You can name various STIs and explain how they can be prevented.

- Learning how to do research 1
- Practical activities 3 and 4

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES	
	4.5.10	4.5.11
Remembering	1abcd, 2, 5a	3b
Understanding	1e, 4	3acd, 4
Using	5bcd, 6, 7, 10ac	8a, 10ac
Analysing	9, 10bd	8b, 10bd

Sexual intercourse can lead to the woman becoming pregnant. If you don't want that, you use contraceptives. Condoms also protect you from sexually transmitted diseases.

CONTRACEPTION

Contraception or birth control means that a woman – usually together with a man – decides whether she wants a baby or not. If the woman does not want to become pregnant, she and/or the man can use **contraceptives**. *Contra* means 'against' and the *ception* part is a shortened form of 'conception', which means the start of pregnancy (fertilization and implantation). In fertilization, the nucleus of a sperm cell fuses with the nucleus of an egg cell (ovum). That gives a fertilized egg cell. The fertilized egg cell can grow into a baby in the womb.

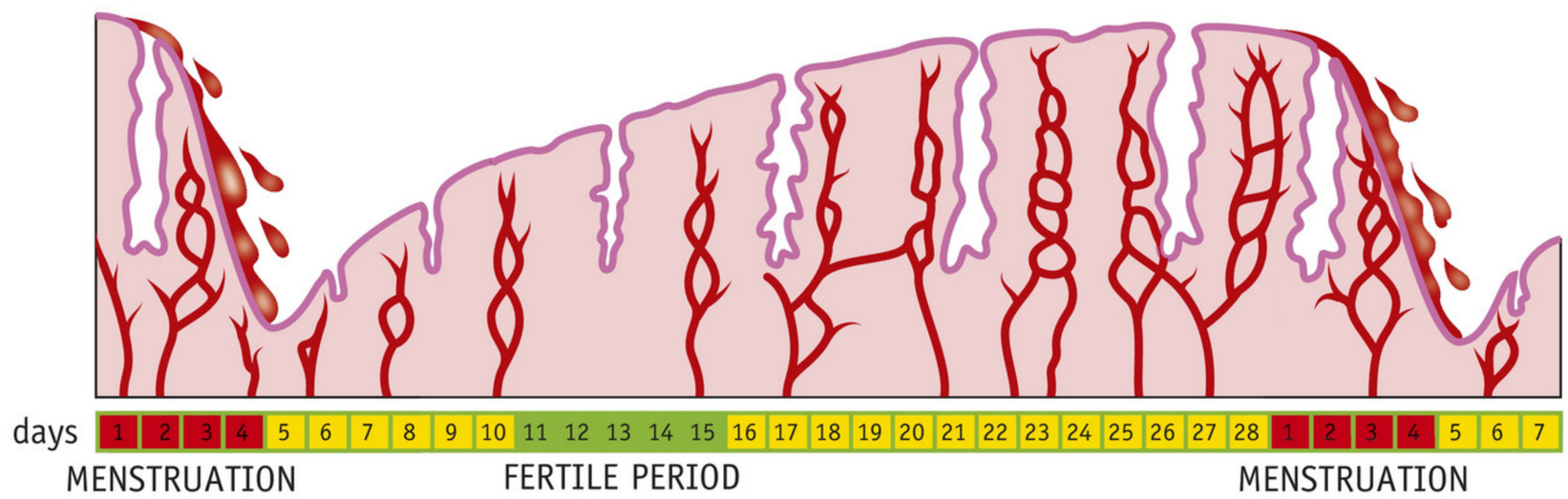
fig. 1 A condom and the pill.

Contraceptives prevent fertilization from taking place. The two best-known contraceptives are condoms and 'the pill' (see figure 1). The pill in particular is reliable. That means that the chance of a woman becoming pregnant is very small if she is 'on the pill'.

UNRELIABLE METHODS

After ovulation, an unfertilized egg cell only lives for 12 to 24 hours. Sperm cells can continue to live inside a woman's body for two to three days after the ejaculation. So there is only a short period of about five days every four weeks when sexual intercourse is likely to result in an egg cell being fertilized. This is called the fertile period. It lasts from about three days before ovulation to about one day after ovulation (see figure 2).

fig. 2



One of the oldest ways of preventing pregnancy is periodic abstinence: the **rhythm method**. The man and woman do not have sexual intercourse during the 'fertile period' of about five days. You cannot generally determine precisely when the ovulation will take place. Some women's ovulations occur earlier or later than the average. The rhythm method is therefore very unreliable. That means the woman can still become pregnant. In particular, women who menstruate irregularly can easily end up with an unwanted pregnancy.

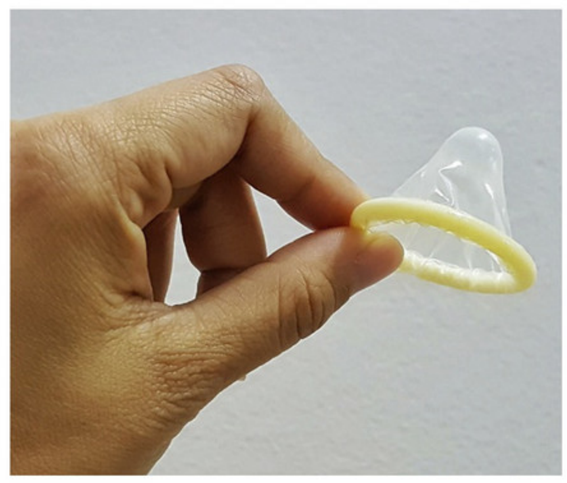
Another unreliable method is **coitus interruptus** (the **withdrawal method**). The man removes his penis from the vagina when he feels his ejaculation is about to happen. Ejaculation then takes place outside the vagina. But there may be pre-ejaculation fluid coming from the penis before ejaculation and this pre-ejaculation fluid often also contains sperm cells. That means that this method is also very unreliable.

THE CONDOM

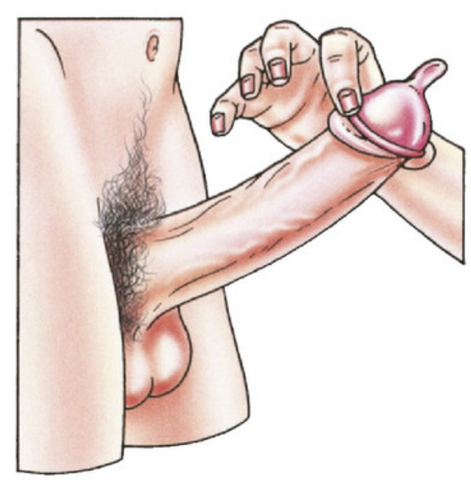
A **condom** is a latex sheath that is placed over the erect penis (see figures 3 and 4). The sperm is collected in the condom and therefore does not end up in the vagina. After use, the condom should be checked to make sure it doesn't have any tears. Then you tie a knot in it and put it in the rubbish bin.

fig. 3 You can buy condoms at a pharmacy.

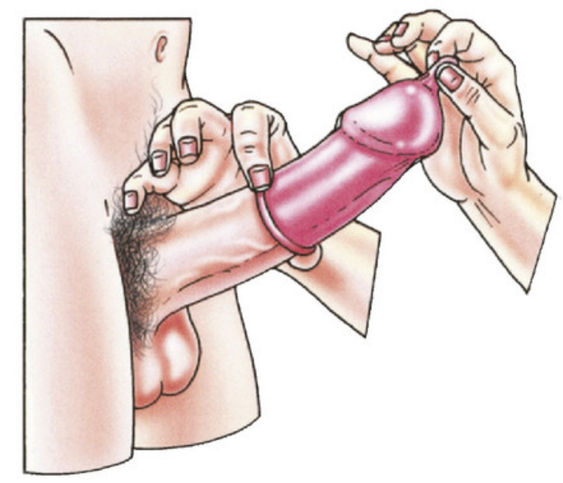
fig. 4 How to use a condom.



1 Remove the condom from the packaging.



2 Put the condom over the head of the penis.



3 Hold the end of the condom in place with one hand and roll it down over the penis with the other hand.

Condoms are simple, cheap and reasonably reliable. You can only use each condom once. A disadvantage is that lovemaking has to be interrupted to put the condom on. A benefit is that a condom protects against the transmission of bacteria and viruses.

Only use condoms that have a CE safety mark (see figure 5). And be careful to observe the expiry date stated on the packaging. Novelty condoms (see figure 6) are made for fun. They are not suitable for safe sex.

fig. 5 CE safety mark and expiry date.

fig. 6 Novelty condom (not safe).

THE PILL

The **pill** (the **contraceptive pill**) is the most widely used method of contraception. The pill contains hormones that stop a woman getting pregnant. The hormones make sure that no egg cells are released (there is no ovulation). The hormones also make the mucus in the cervix thicker, which means sperm cells cannot get through easily. The hormones also affect the womb wall: any fertilized egg can't find a place to attach itself to and grow. The pill is a highly reliable method of contraception.

The pill has to be taken every day, usually with a break of one week every fourth week. Light menstruation takes place during the week with no pills. For that reason, the pill is sometimes also prescribed for girls or women who have very painful or irregular periods.

The tablets come in a blister-strip pack on which the days of the week are marked (see figure 7). That way, the woman knows immediately if she forgot to take the pill one day. If you do forget to take the pill, you are *not* fully protected against pregnancy until the next menstruation.

If you want to start using the pill, you will need a prescription from your GP. After that, you can keep on collecting the pill from the pharmacy. The GP and pharmacist will give you information about how the pill works and how to use it.

fig. 7 Various contraceptive pills.

EMERGENCY MEASURES

Sometimes something goes wrong. A woman may realize after sexual intercourse that she had forgotten to take the pill. The condom may tear or slip off. In such cases, emergency measures are possible to prevent a pregnancy. A woman can also take these measures if she was forced to have sexual intercourse.

The **morning-after pill** is a pill that contains large amounts of hormones. The pill must be taken within three days (72 hours) after sexual intercourse. The morning-after pill works best if it is taken within twelve hours after sex. The morning-after pill can make the woman feel very sick, so it is important to make sure the pill is not vomited back up again. The morning-after pill can be obtained without a prescription from drugstores and pharmacies, but should not be used too often. It is an emergency measure, not a contraceptive.

When a woman is pregnant, she does not menstruate. If the menstruation does not start on the day it normally would, she is **over time**. To find out whether she is pregnant, she can go to her doctor or do a pregnancy test (see figure 8). She urinates on the end of the stick. The test measures the hormones in the urine and shows whether or not the woman is pregnant.

fig. 8 Pregnancy test.

A woman who became pregnant without intending to can choose to terminate the pregnancy. She chooses to have an **abortion**. The woman might also choose an abortion for medical reasons or because of practical problems. The organization FIOM (www.fiom.nl) can help her make this decision.
If a woman's menstruation is less than 16 days late, the abortion can take place immediately. If she is late by more than that, there is a mandatory legal reflection period of five days. The reflection period starts when the woman discusses her choice with a doctor.

Abortion is allowed up to the 24th week of pregnancy. In practice, doctors apply a limit of 22 weeks. The method used depends on how long the woman has been pregnant. Up to the seventh week of pregnancy, the woman can take an abortion pill. From the eighth week onwards, the womb is emptied by suction through a tube. The procedure after the 13th week of pregnancy is more major.

In the Netherlands, abortion is allowed under certain conditions and it is free and safe. That is not the case everywhere. People have very different opinions about abortion. Some people think that the woman should be allowed to choose ('boss of her own body', see figure 9.1). Other people call it the murder of an unborn child (see figure 9.2). There are also others for whom it depends on how the woman got pregnant.

fig. 9 Different opinions about abortion.

1

2

STI

There are diseases that you can only get through intimate physical contact with an infected person. These diseases are called **sexually transmitted infection** (**STIs**) or **venereal diseases** (**VD**). You can become infected through sexual intercourse or other forms of sexual contact between the sexual organs, mouth or anus. You can't get an STI from a dirty toilet or by drinking from someone else's glass because the pathogens that cause STIs soon die when they are outside the human body.
The commonest STI in the Netherlands is chlamydia (see table 1). AIDS is perhaps the most widely known, but it is much less common. The pathogen that causes chlamydia is a bacterium; in AIDS it is a virus. To find out whether you are infected with chlamydia, HIV or another STI, you can do an **STI test**. You can do this at one of the Municipal Health Service STI centres.

Table 1 Number of diagnoses in the Netherlands in 2018.

STI	At SHCs*	At family doctors	Total
Chlamydia	21,021	39,800	60,821
Genital warts	1314	41,900	43,214
Genital herpes	426	25,800	26,226
Gonorrhoea	7362	9500	16,862
Syphilis	1224	unknown	(1224)
HIV	249	unknown	(249)
Hepatitis B and C	112	51 (doctors + hospitals)	163

* *SHC stands for Sexual Health Centre, for example run by the Municipal Health Service or Sense.*
Source: RIVM, Sexually transmitted infections in the Netherlands in 2018.

CHLAMYDIA

The bacterium that causes **chlamydia** is mainly found in people aged between 15 and 30. The bacterium doesn't cause any symptoms in two thirds of all infected women and half of all infected men. These people don't notice the infection, but they can still pass chlamydia on to other people with whom they have sexual contact.
The chlamydia bacterium can cause inflammation in the anus, the cervix or the urethra. Men may notice a (watery) discharge from the penis, pain when urinating, and pain in the scrotum. Women may notice pain when urinating, pain during sexual intercourse and pain in the lower abdomen. If chlamydia is not treated in time, the inflammation can spread to the Fallopian tubes or epididymis. Women can become infertile (unable to have babies).

HIV

AIDS is caused by a virus called **HIV** (human immunodeficiency virus). Someone can be infected without having any symptoms. Someone who is infected with HIV is **seropositive**. You can get the virus through unsafe sex (without a condom), from an infected person's blood, semen, vaginal fluid or pre-ejaculation fluid.
Someone who is seropositive should start taking **HIV inhibitors** as soon as possible. These medicines slow down the reproduction of the virus in the body. It is not possible for someone to be cured of a HIV infection. The later they start taking HIV inhibitors, the greater the likelihood that they will get full-blown AIDS. AIDS can be fatal.
When someone has **AIDS**, their immune system is affected. That makes this person susceptible to all kinds of diseases such as intestinal inflammation, pneumonia or skin cancer. Someone with AIDS can get multiple diseases at the same time. So AIDS doesn't have any specific symptoms.

KNOWLEDGE

1

a What is the function of contraceptives?
b Fill in the correct number of days. You may choose between: *1 day – 2 to 3 days – 3 to 4 days – 5 days*.

- Egg cells live for ..... .
- Sperm cells survive in a woman's body for ..... .
- In the rhythm method, a couple do not have sexual intercourse for ..... .

c In the rhythm method, a couple do not have sexual intercourse during *menstruation / ovulation / the fertile period*. This method of contraception is *reliable / unreliable*.
d Why is coitus interruptus (withdrawal) not a reliable method of contraception?
e Explain why a man needs self-control to practice coitus interruptus.

2

a Condoms with the CE safety mark are *not / reasonably / very* reliable.
b How does the pill stop a woman from becoming pregnant?
c If a woman forgets to take the pill, she *is / is not* fully protected against pregnancy.
d After she has had sex with her boyfriend, Rosie discovers that she forgot to take the pill. If Rosie doesn't want to become pregnant, she needs to take the morning-after pill within ..... days of having sex.
e Abortion is allowed up to week ..... of the pregnancy.

3

a Chlamydia is the commonest STI in the Netherlands.
Explain why chlamydia is so common.
b Chlamydia is caused by a *bacterium / virus*.
AIDS is caused by a *bacterium / virus*.
c If someone's immune system is weakened and the body is no longer able to resist pathogens, the person is infected with *AIDS / chlamydia / gonorrhoea / HIV / syphilis*.
d If someone is seropositive, they *have / do not have* AIDS.
Medicines can *cure / slow down* the disease.

4 **Summary**

Complete figure 10.

fig. 10

Contraception:

- Unreliable methods:
- Widely used methods:
- Emergency measures:

STIs:

- You can only get from:
- Can be prevented by:

Chlamydia:

- In women, it can cause:

AIDS:

- The immune system:
- Infection:
- Seropositive:

INSIGHT

5 Figure 11 is a schematic drawing of a woman's menstrual cycle. Her cycle is very regular and always lasts 28 days.

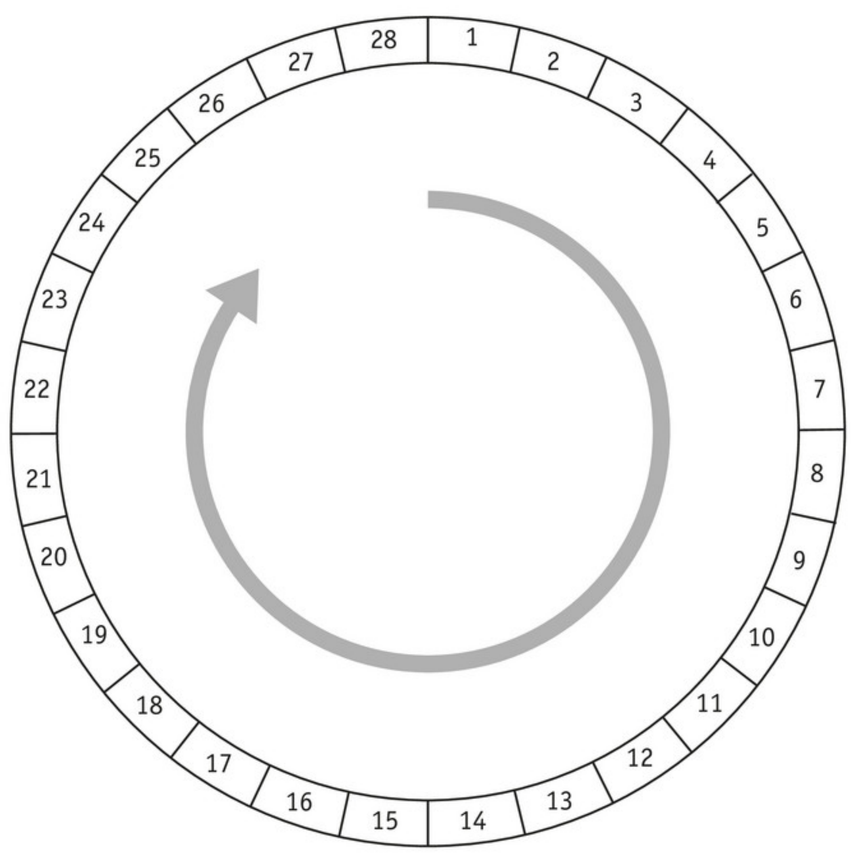
a She has her menstruation in the first five days. Colour those days red.

b Colour the day on which ovulation probably takes place green.

c Colour the days on which sexual intercourse could lead to fertilization of the egg cell blue. Label these days *fertile period*.

d Ovulation has not yet taken place on day 11 of the menstrual cycle. Explain why sexual intercourse on day 11 can still lead to fertilization.

fig. 11

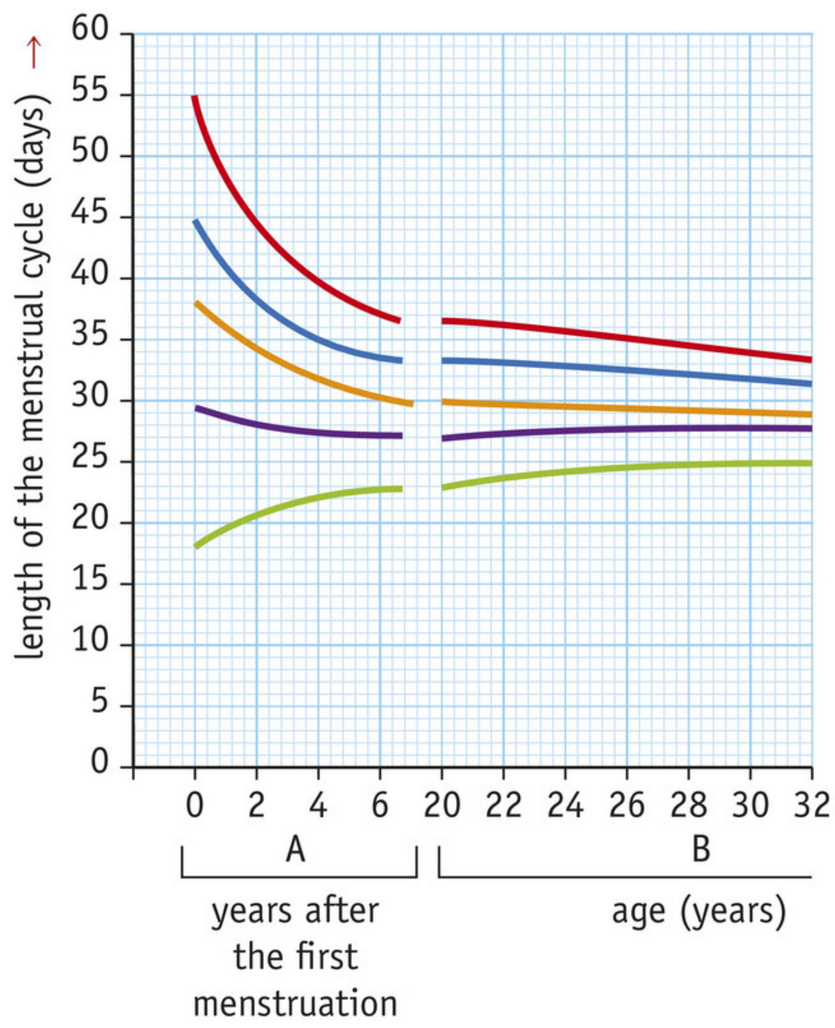


6

a Figure 12 shows the lengths of the menstrual cycle for five women.
The length of the menstrual cycle changes most at age *16 / 32*.

b The rhythm method is unreliable at any age.
At which age is the rhythm method more unreliable: at age 16 or at age 32? Explain your answer.

fig. 12 Length of the menstrual cycle for five women.



7

Various types of contraceptive pill can be obtained. Figure 13 shows part of the patient information leaflet for a certain brand. This part of the leaflet shows what the woman should do if she has forgotten to take a pill.
Figure 14 shows three women. They have all forgotten to take one or more pills.
Five options, labelled A to E, are listed in the diagram in figure 13.

a Which option(s) can each of the three women choose to prevent pregnancy?
Lieve: *A / B / C / D / E*
Wai Yan: *A / B / C / D / E*
Suzy: *A / B / C / D / E*

b Wai Yan is afraid she might be pregnant and plans to visit the doctor on Tuesday.
Will she still be on time for the morning-after pill? Explain your answer.

c Before Wai Yan started using the pill, she assumed that she would always be able to take the morning-after pill the next day if she had sexual intercourse.
Why is that not a good idea?

d Jade finds out she is nine weeks pregnant. She doesn't want the pregnancy. She has an abortion by vacuum aspiration (with a suction pump).
What parts are removed from the womb?

fig. 13

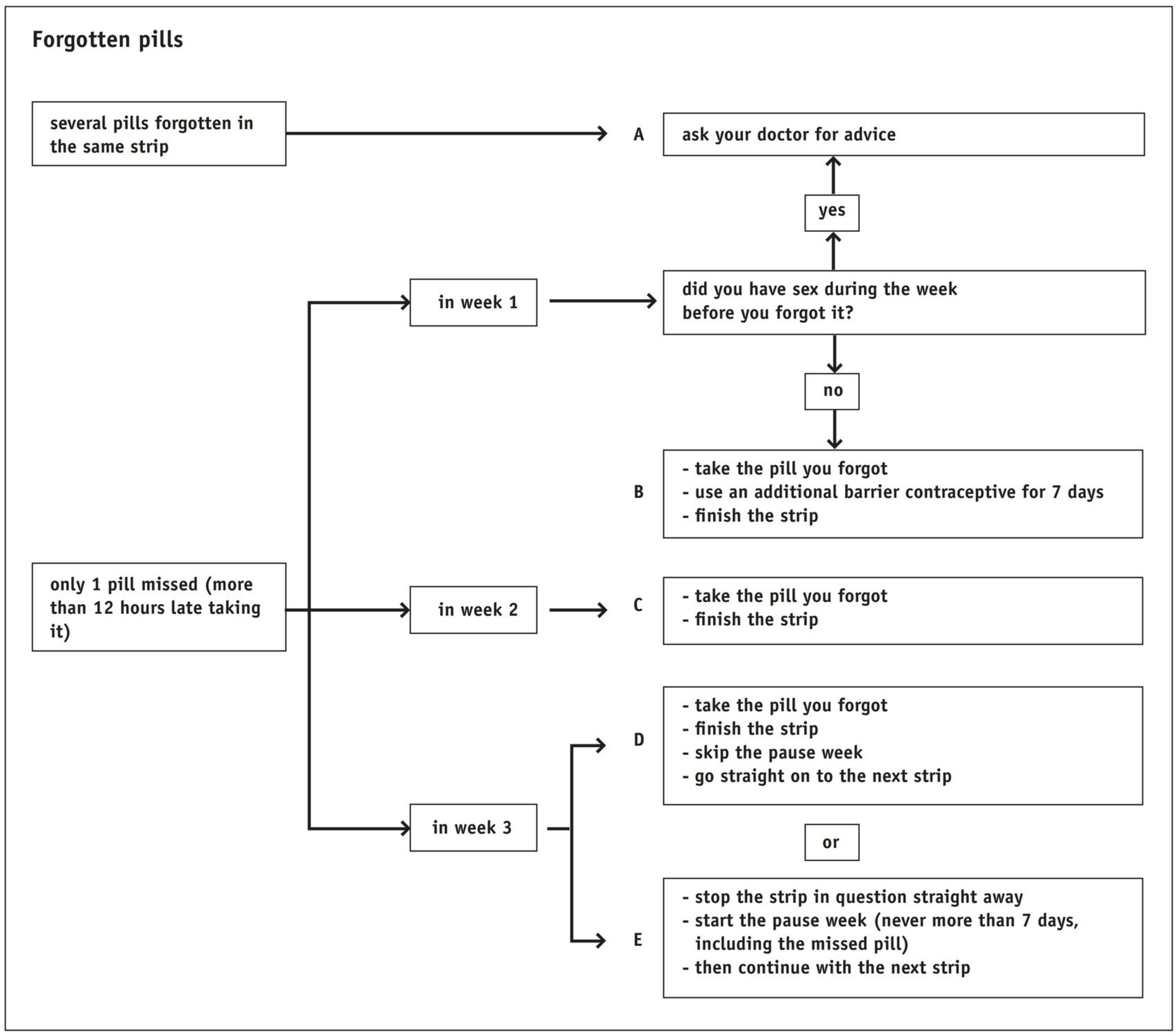


fig. 14

On Monday evening, Louise realizes that she forgot to take the pill that Sunday evening. She has not had sexual intercourse in the past few weeks.

On Monday evening, Wai Yan realizes that she forgot to take the pill on Saturday evening and Sunday evening. She had sexual intercourse on Sunday evening.

On Monday evening, Susie realizes that she forgot to take the pill that Sunday evening. She had sexual intercourse on the previous Friday.

8

a The organization SOA AIDS Nederland focuses on the sexual health of young people. Which action fits with which problem?

A	Chlamydia is the most common STI among young people.	○	○ 1 help in preventing pregnancies
B	In 2018, there were 1,984 teenagers in the Netherlands who had a baby.	○	○ 2 free tests for chlamydia for young people under the age of 25
C	Many girls have suffered unacceptable sexual behaviour.	○	○ 3 teaching healthy sexual behaviour from a young age, such as using a condom to prevent STIs
D	One in three young people were not expecting it when they had sex for the first time.	○	○ 4 encouraging resilience in young people and encouraging healthy sexual behaviour

b There are all kinds of old wives' tales about STIs.
Which statements are correct?

- ☐ A If you have had a particular STI once, you can never get the same STI again.
- ☐ B If your partner has an STI, you can see that immediately.
- ☐ C An STI eventually goes away of its own accord.
- ☐ D You can infect someone else with an STI even if you don't have any symptoms.
- ☐ E Lesbian women cannot infect one another with an STI.
- ☐ F STIs can make you infertile.

+ 9

Read the text 'hCG' in figure 15.

a Until 1969, frogs were used to determine whether a woman was pregnant (the frog test). The urine of a woman who might be pregnant was injected into a male frog. If the woman really was pregnant, the frog produced sperm cells three hours later. Explain how this is possible.

b Some pregnant women do not make enough hCG.
What consequences can this have for the fertilized egg cell?

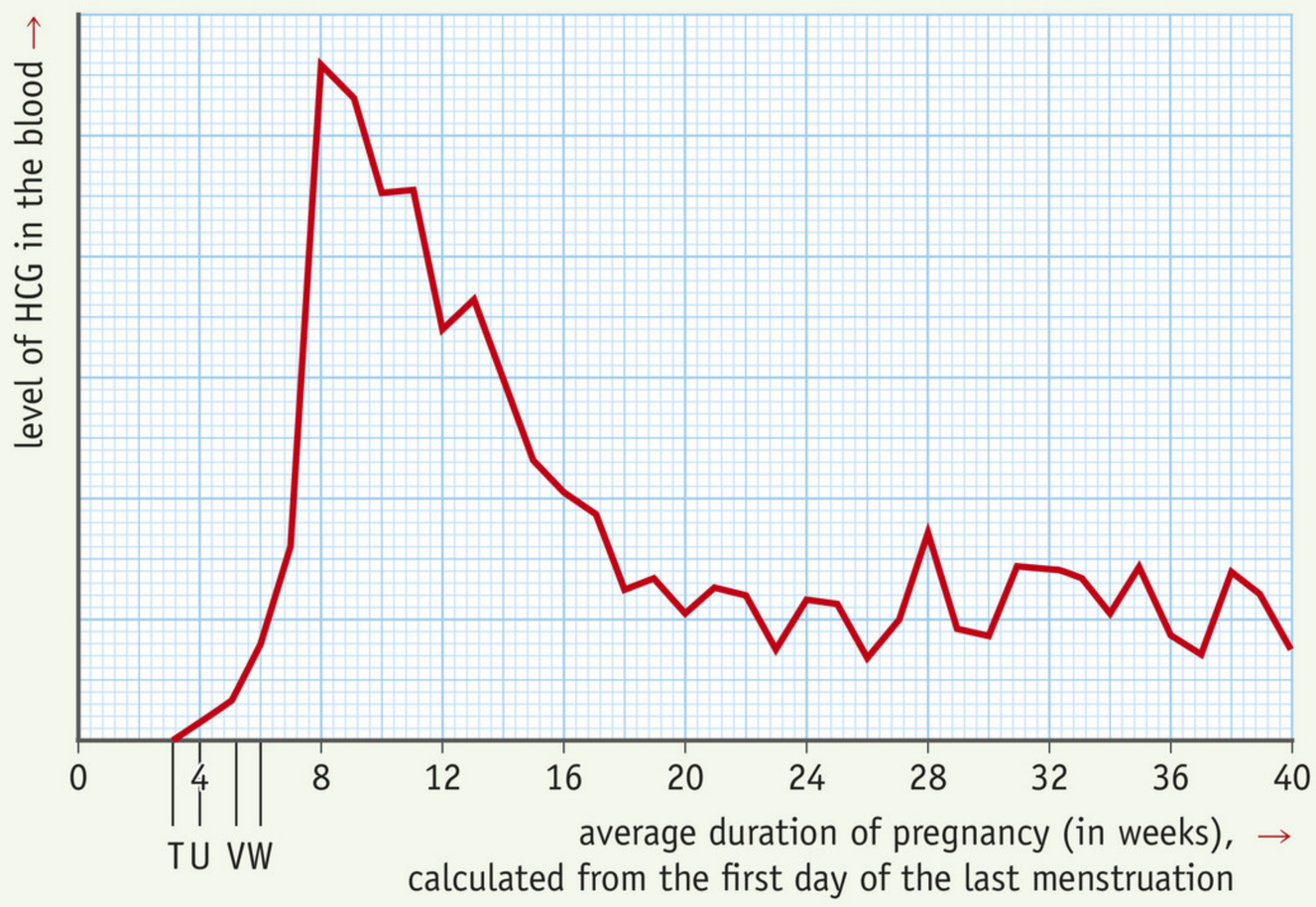
c The graph shows the change in the amount of hCG in the blood of a pregnant woman. Four points in time are labelled with letters.
Explain what makes the production of hCG start at time T.

d A pregnancy test can detect hCG in your urine from about 28 days after your last menstruation started, but you are advised only to do the test five weeks after the last menstruation.
Using the information in the graph, explain why it is better to do the pregnancy test after five weeks.

fig. 15

hCG

If a woman has the hormone hCG in her blood or urine, that is evidence that she is pregnant. It is made by the fertilized egg cell from the start of the pregnancy. Pregnancy tests detect this hormone hCG in the pregnant woman's urine.
hCG makes sure no more egg cells ripen in the ovary. It also makes sure there are no more menstruations, which would lead to the discharge of the womb lining.



HOW IT FITS TOGETHER the living world

TRYING ON CONDOMS AT UTRECHT RAILWAY STATION

In 2018, SOA AIDS Nederland opened the first pop-up condom shop in the world at Utrecht railway station. You could even try the condoms on. There was a fitting room, a condom consultant, a wide selection of condoms and a device to check your own size. SOA AIDS Nederland wanted to use the pop-up condom shop to raise awareness about the use of condoms. That is badly needed because the use of condoms has fallen a lot among sexually active young people. In 2009, 80% of young people used a condom in sex with a new partner, but that percentage had fallen to 55% by 2017. There has also been an increase in the number of casual partners among young people. More and more people are getting tested for STIs; one in five people turn out to have an infection.

fig. 16 The pop-up condom shop at Utrecht railway station.

10 Read the text 'Trying on condoms at Utrecht railway station'.

a There has been an increase in the number of casual partners among young people. Why will this, in combination with decreasing use of condoms, lead to a rise in the number of STI infections?

b Condoms don't give 100% protection against all STIs. For example, you can still get genital herpes or genital warts, or pass them on.
Explain how that is possible (assuming the condom does not tear).

c Many women who are on the pill and do not have a permanent partner still use condoms. Why is that sensible?

d If a man has sexual intercourse with a woman and uses a condom, he should remove his penis immediately from the vagina after ejaculating.
Explain why this is needed.

Go to the *Flash cards* and the *Test yourself* section.

6 Pregnancy

LEARNING OBJECTIVES

4.6.12 You can describe the fertilization of a human egg.
4.6.13 You can describe how a pregnancy progresses.
4.6.14 You can explain what a prenatal testing is and give some examples.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES					
	4.6.12	4.6.13	4.6.14	4.2.3*	4.3.5*	4.5.10*
Remembering	1a	1cde, 2a				
Understanding	1b, 4, 5ab, 7b	1f, 2b, 4	3, 4, 10a			
Using	5c, 6, 7d	5d	8b			
Analysing	7ac	5e, 9	8a, 10c	10b	10b	10c

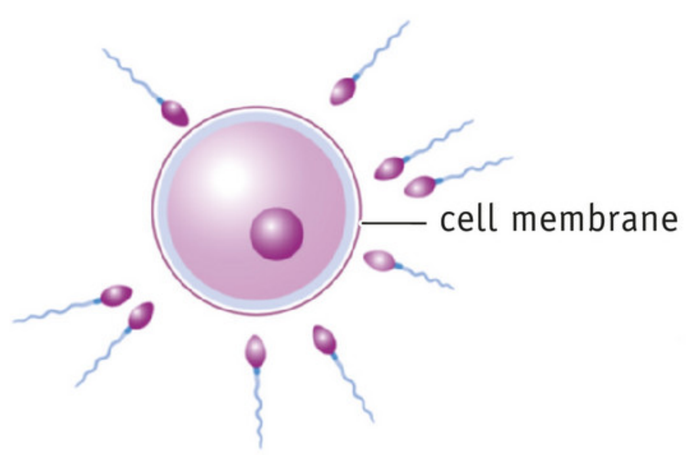
* You can find this learning objective in another Basics section.

The egg cell can only stay alive for longer if it is fertilized by a sperm cell after ovulation. The fertilized egg cell can grow into a baby in the womb.

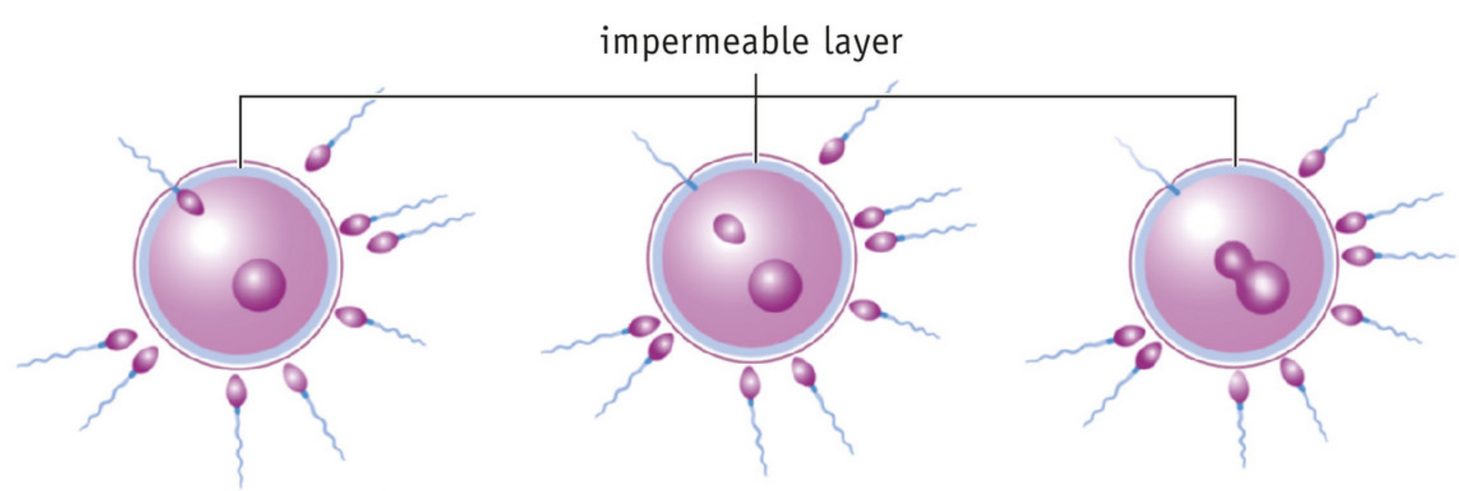
FERTILIZATION

During sexual intercourse, semen can get into the vagina. The sperm cells then move about using the flagellum (tail) towards the womb and the Fallopian tubes. If they meet an egg cell (ovum), they can fertilize it. The **fertilization** of an egg cell by a sperm cell takes place inside a Fallopian tube. During fertilization, the nuclei of a male sex cell and a female sex cell fuse together.
In fertilization, the head of the sperm cell penetrates the egg cell (see figure 1). The flagellum of the sperm cell remains outside. Once the head (nucleus) of a sperm cell has entered the egg cell, the outer layer of the egg cell becomes impenetrable. It is then no longer possible for other sperm cells to penetrate the same egg cell.

fig. 1 Fertilization of an egg cell (schematic).



1 Ovum surrounded by sperm cells



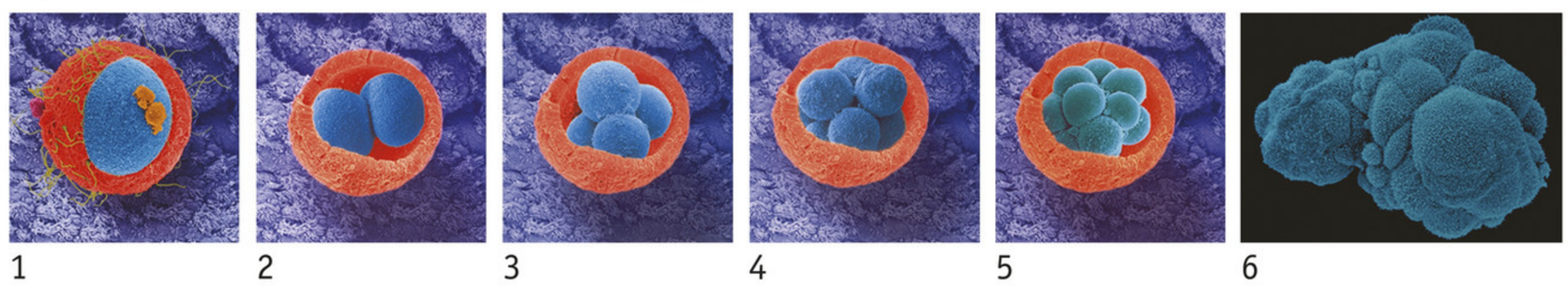
2 The nucleus of one of the sperm cells penetrates the egg cell.

3 The nuclei of the sperm cell and ovum fuse (fertilization).

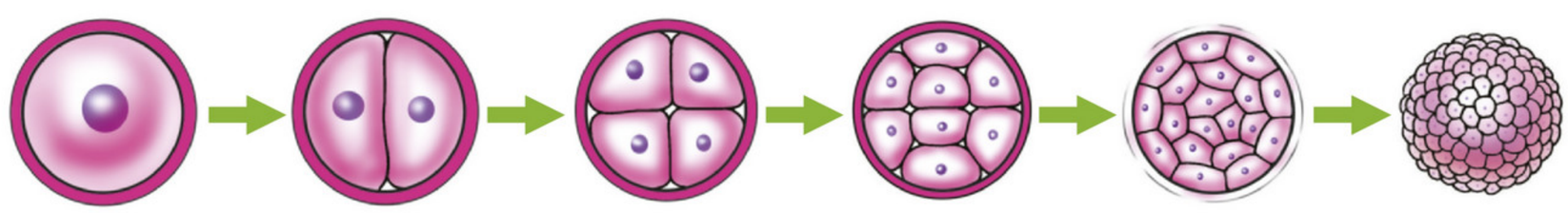
IMPLANTATION

The fertilized egg cell immediately divides several times (see figure 2). The cluster of cells that this produces is carried down the Fallopian tube to the womb. The womb lining will have become very thick after the ovulation and contains a lot of blood vessels.
The cluster of cells attaches itself to the womb lining. This is called **implantation** (see figure 3). The womb lining will in that case not become detached and there will be no menstruation. The woman is pregnant. The woman doesn't have her period at all during the pregnancy.
The implantation of the embryo takes place five to seven days after ovulation. That cluster of cells grows to become a baby. The child is born about 38 weeks after fertilization.

fig. 2 The first divisions of the fertilized egg cell.

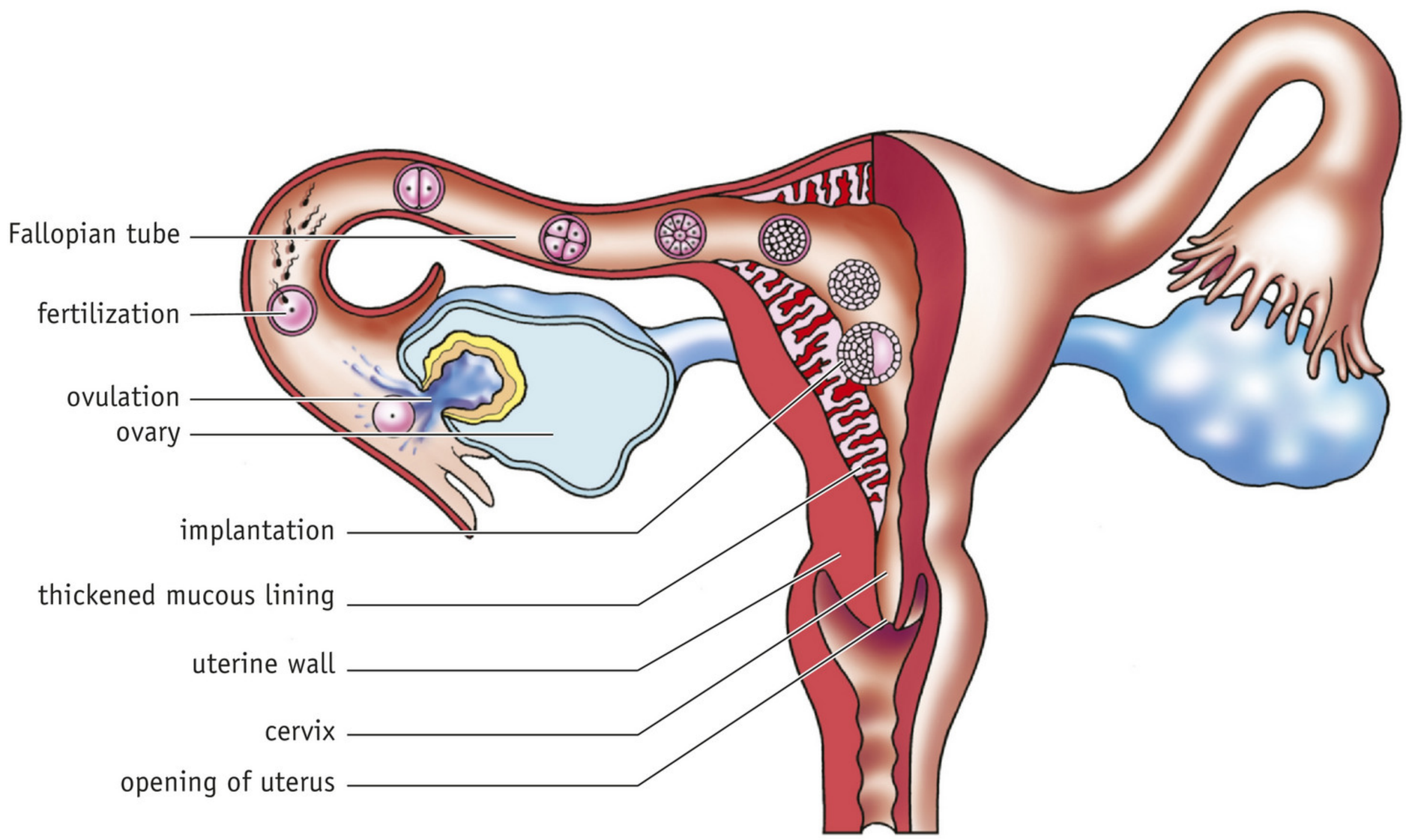


1 microscope photos



2 schematic drawing

fig. 3 The clump of cells is transported to the womb where it implants in the womb lining.

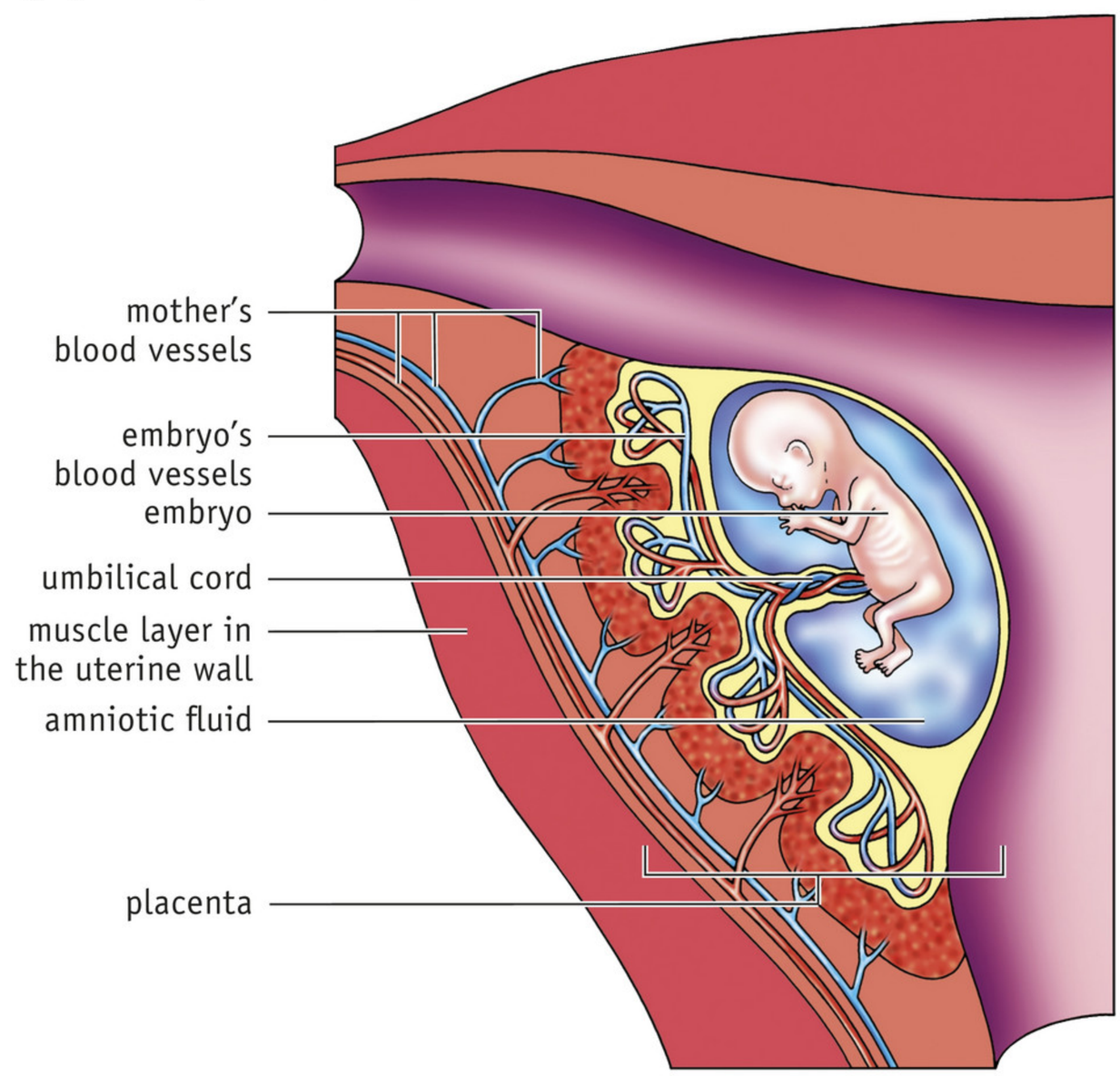


PREGNANCY

The child that develops in the womb is called the **embryo** for the first few weeks. From the eighth week after fertilization through to the birth, it is called a **foetus**. During the first weeks of the pregnancy, the womb lining provides nutrients for the embryo. After that, the **placenta** forms (see figure 4). This is a special part of the womb lining in which blood from the blood vessels of the embryo flows very close to the mother's blood. This allows substances to be exchanged between the blood of the mother and the blood of the embryo. The mother's blood does not flow *through* the embryo; it remains separated from the embryo's blood by thin membranes.

The embryo is joined to the placenta by the **umbilical cord**. Oxygen and nutrients cross from the blood of the mother to the blood of the embryo. Waste products cross from the blood of the embryo back to the blood of the mother.

fig. 4 Embryo in the womb.

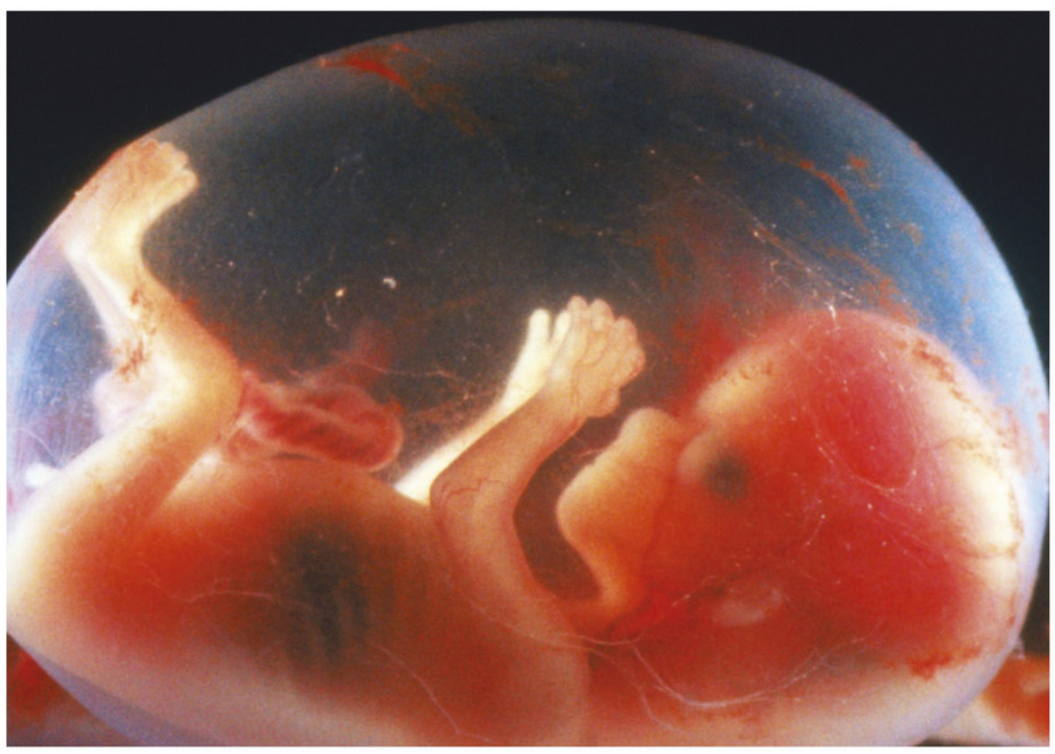


There are two **amniotic sacs** around the foetus. Inside the amniotic sac is the **amniotic fluid** (see figure 5). The foetus floats in the amniotic fluid. This protects it against knocks, dehydration and temperature changes. On top of that, it makes it easy for the foetus to move. After nine months of pregnancy, the baby is 'ready' to be born.

fig. 5 Various stages in the development of an unborn child.

1 embryo, aged six weeks

2 foetus, aged eight weeks



3 foetus, aged twelve weeks

4 foetus, aged five months

ULTRASOUND SCAN AND PRENATAL TESTING

When a woman is about ten weeks pregnant, she usually has an **ultrasound scan**. Sound waves are used to make a picture of the foetus in the womb (see figure 6). The midwife can use the scan to determine exactly when the woman became pregnant and therefore roughly when the baby will be born.

During the pregnancy, tests can be carried out to see whether the mother has a relatively high risk of a baby with a congenital abnormality or hereditary disease. This is called a **prenatal testing** (*pre* = before; *natal* = birth). The baby's sex can also be determined. Prenatal tests are not compulsory.

The first prenatal test a mother is offered is the **combined test**. This takes place between the ninth week and fourteenth weeks of pregnancy. The combined test shows whether there is a risk of a baby with Down's syndrome. The test consists of a blood test from the mother and a nuchal (neck) fold measurement of the foetus. An ultrasound scan is used for the nuchal fold measurement. The results of the two tests are used to calculate whether there is an increased risk of a baby with Down's syndrome.

Since 2017, pregnant women in the Netherlands have been able to choose to have a NIPT, but only if they take part in scientific research. **NIPT** stands for non-invasive prenatal test. A blood sample is taken from the mother and tested. The blood contains some DNA from the placenta. This is nearly always the same DNA as the baby's DNA. The blood test may show that there is an increased risk of a baby with a hereditary disease. The NIPT can be done from the eleventh week of pregnancy.

Another ultrasound scan can be carried out after about the twentieth week of pregnancy. In this **anomaly scan**, the foetus is examined to check for various congenital abnormalities of the heart, brain, organs and limbs. The sex of the foetus sex can also be determined.
In addition to the (free) ultrasound scans needed to examine the foetus, expecting parents can also ask for a **non-medical prenatal scan**. The scan for non-medical purposes is just so they can see the foetus. That can be done in 3D (see figure 6.2) or 4D (a video).

fig. 6 Ultrasound scans.

1 anomaly scan

2 non-medical prenatal scan

KNOWLEDGE

1

a Why can an egg cell only be fertilized by a single sperm cell?

b Put these events that lead to fertilization in the correct sequence.

..... During sexual intercourse, sperm cells enter the vagina.

..... The outer layer of the egg cell becomes impenetrable for other sperm cells.

..... The nuclei of the sperm cell and ovum fuse (fertilization)

..... The head of a sperm cell enters an egg cell.

..... Sperm cells travel from the womb to a Fallopian tube.

..... Sperm cells travel from the vagina to the womb.

c A cluster of cells grows into *an embryo* / *a foetus*. After eight weeks, it is called *an embryo* / *a foetus*.

d What provides food for the embryo after a few weeks?

○ A the womb lining
○ B the placenta
○ C food reserves in the egg cell

e During pregnancy there *are* / *are no* ovulations and there *is* / *is no* menstruation.

f The embryo is joined to the placenta by the umbilical cord.
In what directions are oxygen, nutrients and waste products transported in the blood vessels in the umbilical cord?

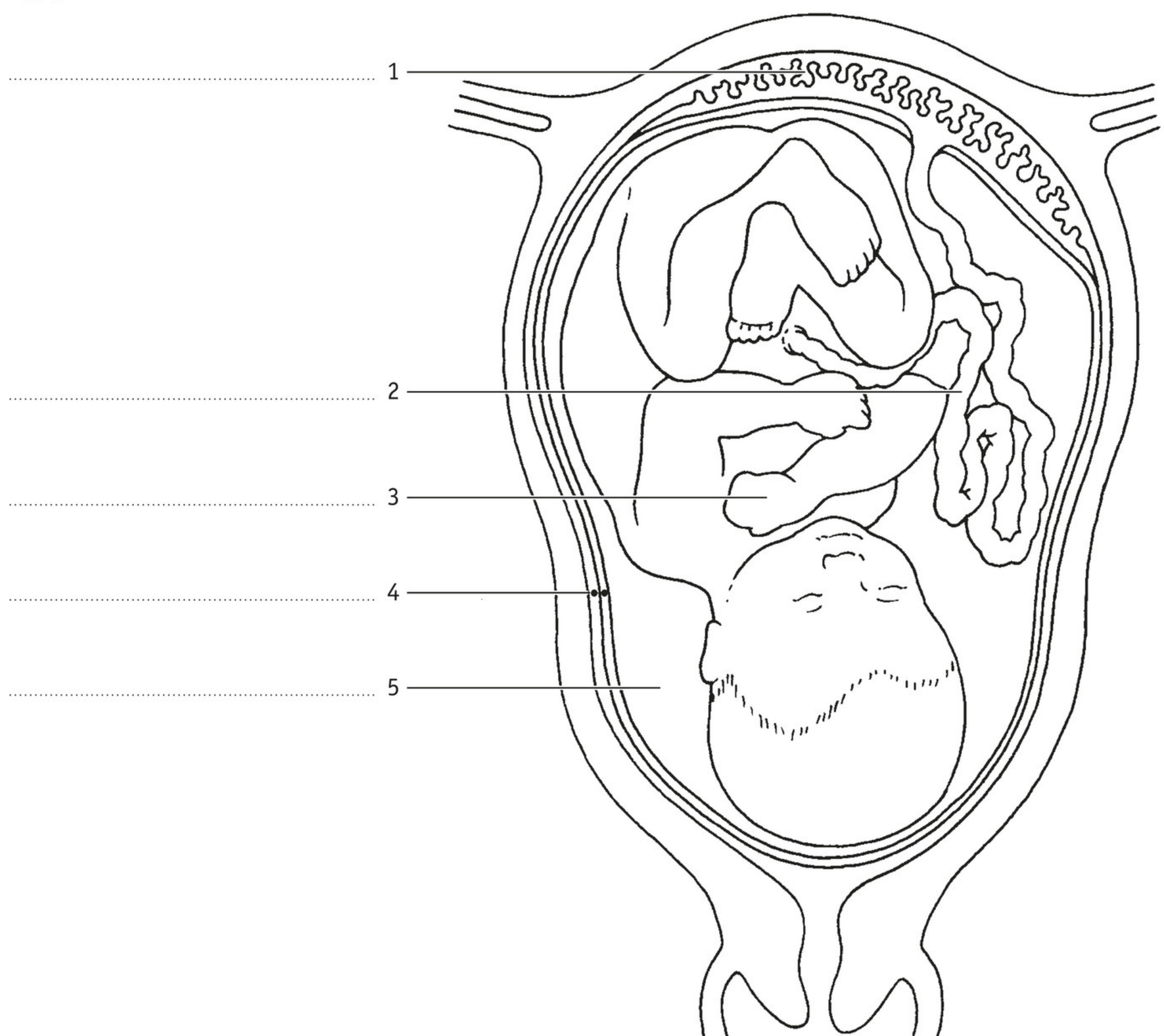
2

Figure 7 shows a drawing of a foetus in the womb.

a Write down the names of the numbered parts.

b Colour in the various parts in the drawing. Use a different colour for each part.

fig. 7



3 Which prenatal testing belongs with each description?

A Blood containing DNA from the placenta is taken from the mother and tested. ◯

B A blood test and a nuchal fold measurement are performed. ◯

C Sound waves are used to make a picture of the foetus in the womb. ◯

◯ 1 combined test

◯ 2 ultrasound scan

◯ 3 NIPT

4 **Summary**

Complete the infographic in figure 8.

fig. 8

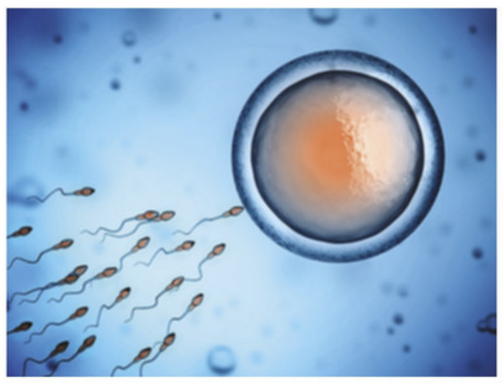
Implantation:

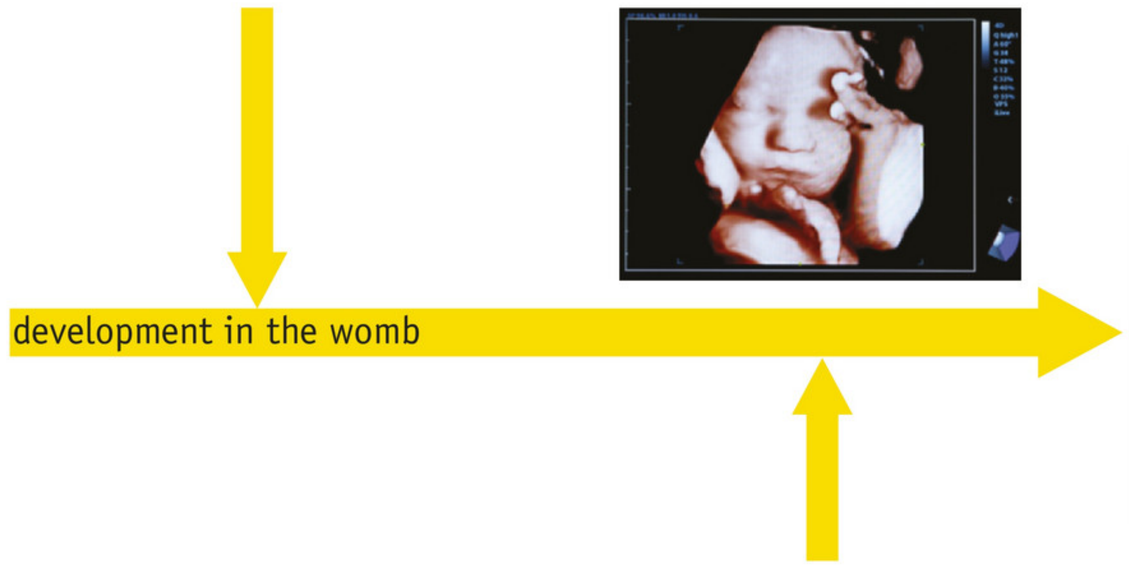
Nutrition:

- first weeks:
- then:

The following go via the blood in the umbilical cord:

Amniotic sac consisting of two membranes containing amniotic fluid:





Fertilization:

An ovum can only be fertilized by a single sperm cell because:

Prenatal examination:

INSIGHT

5 Rosie has marked when she had a period in the calendar in figure 9. Her menstruations are very regular – every four weeks.

a When should her next menstruation be?
- ○ A On 29 January
- ○ B On 12 February
- ○ C On 16 February

b When will ovulation probably take place?
- ○ A On 29 January
- ○ B On 12 February
- ○ C On 16 February

c Rosie has sexual intercourse and her egg cell is fertilized.
In which week is implantation in the womb lining likely to take place?
- ○ A week 5
- ○ B week 6
- ○ C week 7

d Rosie's pregnancy goes smoothly. She has the baby in the week of the date on which the baby was due.
In which month is the baby born?
- ○ A September
- ○ B October
- ○ C November

e Pregnancy lasts 40 weeks on average.
Is Rosie's baby 40 weeks old when it is born? Explain your answer.

fig. 9

ANNUAL CALENDAR

	JANUARY					FEBRUARY					MARCH					
week	1	2	3	4	5	5	6	7	8	9	9	10	11	12	13	14
Mon		5	12	(19)	26		2	9	16	23		2	9	16	23	30
Tue		6	13	20	27		3	10	17	24		3	10	17	24	31
Wed		7	14	21	28		4	11	18	25		4	11	18	25	
Thu	1	8	(15)	22	29		5	12	19	26		5	12	19	26	
Fri	2	9	(16)	23	30		6	13	20	27		6	13	20	27	
Sat	3	10	(17)	24	31		7	14	21	28		7	14	21	28	
Sun	4	11	(18)	25		1	8	15	22		1	8	15	22	29	

6

a Figure 10 shows an ovum and sperm cells of a mouse.
Is it a drawing of a moment after fertilization has taken place? Explain your answer.

b Figure 11 shows a drawing of the reproductive and excretory systems of a mouse. The structure of a mouse's reproductive system is different to the structure of the human reproductive system because a mouse has a womb that is partly split. The functions of the different parts are the same in other respects.

In which part do the egg cells develop? In part *1 / 2 / 3 / 4*

c In which part does fertilization take place? In part *1 / 2 / 3 / 4*

d In which part does implantation take place? In part *1 / 2 / 3 / 4*

e Has implantation already taken place? Explain your answer.

fig. 10

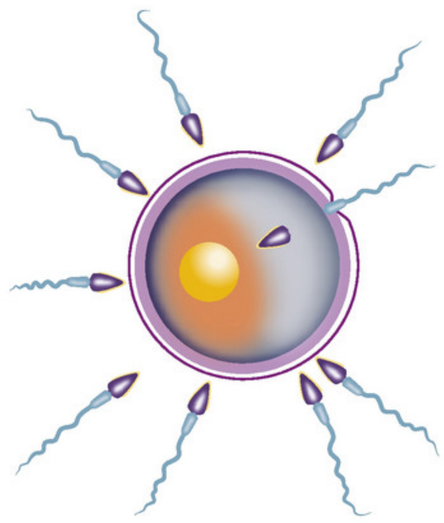
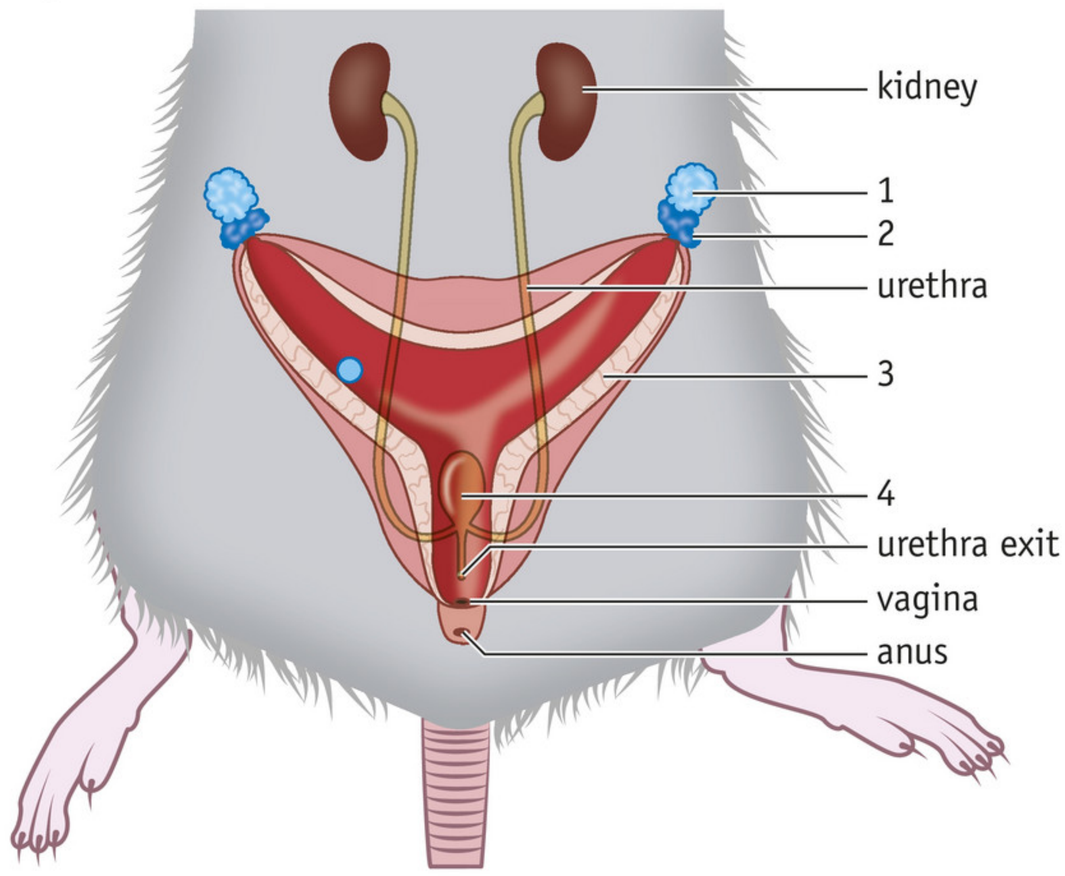


fig. 11



7

a The inside of the Fallopian tubes is covered with cilia (small hairs).
Explain what the cilia do.

b The fertilized egg can't absorb nutrients from its surroundings when it is being transported along the Fallopian tube. That is only possible after implantation in the womb lining.
How does the fertilized egg cell get the nutrients it needs to divide?

c Humans have a fixed number of chromosomes in the nucleus of their body cells: 46. The nucleus of an egg cell and the nucleus of a sperm cell have 23 chromosomes each.
Very occasionally, two sperm cells enter an egg cell at the same time. The fertilized egg cell does not turn into a baby or twins.
Explain why an egg cell that is fertilized by two sperm cells cannot develop into a baby.

d Men are almost never completely infertile but they can have reduced fertility. Often the semen has enough sperm cells but the sperm cells are not mobile enough.
Why is that a problem?

8

NIPT stands for non-invasive prenatal test. A non-invasive test is one where the doctor doesn't need to get inside the patient's body. Prenatal tests that are invasive increase the risk of a miscarriage by about 0.5%.

a Explain why the risk of a miscarriage increases.

b The sensitivity of a test is the probability that the test will identify the condition if the baby has that condition. Scientific research shows that the sensitivity of the NIPT is 99.2%.
Explain why another test is always needed if the NIPT shows the foetus has a certain condition.

+ 9

Read the text 'The twin transfusion syndrome' in figure 12.

a A foetus keeps the amount of amniotic fluid in its amniotic sac stable by drinking from it and urinating. In the twin transfusion syndrome, the foetus that receives more blood has far more amniotic fluid in its amniotic sac than the foetus that gets less blood.
Explain why.

b The foetus that gets less blood also gets less oxygen and fewer nutrients; an ultrasound scan clearly shows that it is tightly contained in the amniotic sac.
What problems does this cause for the foetus that receives less blood?

fig. 12

The twin transfusion syndrome
Identical twins are usually both connected to a single placenta with their own individual umbilical cords. In the network of blood vessels in the placenta, there are points where the vessels from the two halves of the placenta are connected to one another. Blood can then pass from one foetus to the other via these connected blood vessels. That is usually not a problem because both foetuses give as much blood in total as they receive. But one in seven pairs of identical twins have a situation where one foetus gets much more blood than the other. This is called the twin transfusion syndrome.

HOW IT FITS TOGETHER biology in professional life

DIAGNOSTIC MEDICAL SONOGRAPHER

fig. 13

Gijs studied Medical Imaging and Radiotherapy Techniques and specialized as a diagnostic medical sonographer. He mainly does ultrasound scans for pregnancy check-ups.
For the combined test, he measures the thickness of the foetus's nuchal fold using ultrasound. This is used, along with data about the mother, to calculate the chance that the foetus has Down's syndrome. If that chance is more than 1 in 200, it is called an 'increased risk', even though the chance is still quite low.
Older women have a higher risk of babies with Down's syndrome. The chance is less than 1 in 1000 when you are 20, but 1 in 200 when you are 36 and 1 in 29 if you are 45. If there is an increased risk of a baby with Down's syndrome, the woman can choose to have a follow-up test to be sure.

10 Read the text 'Diagnostic medical sonographer'.
In the Netherlands, the proportion of women having a baby who were 36 or older increased from 7% in 1988 to 18.6% in 2016.

a Using the data in the text, explain why this means the chance of babies with Down's syndrome is increasing as a result.
b As a cell ages, it is more likely to be damaged. The increased chance of a baby with Down's syndrome mainly depends on the age of the woman, not the age of the man. Explain why this could be connected to the ages of egg cells and sperm cells.
c More and more pregnant women are deciding to have a combined test. As a result, the number of babies identified with Down's syndrome before birth has increased. Explain why that does not necessarily lead to a decrease in the number of children born with Down's syndrome.

Go to the *Flash cards* and the *Test yourself* section.

How it fits together

LOOKING GOOD, GOOD-LOOKING!

The spring is traditionally the season for falling in love. You decide within three seconds whether you find someone you meet attractive. A lot of factors play a role here, both consciously and unconsciously. One of those factors is appearance.

HORMONES

Which features people find attractive varies across time and cultures. But girls with broad hips and a narrow waist are almost always considered attractive. The ideal ratio is 1 (hips) to 0.7 (waist). When girls have the optimum amount of the hormone oestradiol in their blood, they are highly fertile at the end of puberty and the circumference of the waist is 0.7 times the circumference of the hips. That waist is not as narrow as the classic Barbie doll: her waist is so small that her organs wouldn't even fit in her abdomen. It also turns out that most people find a girl's face most attractive during the fertile part of her monthly cycle. Her lips and face are slightly redder and her voice slightly higher then. In the peak fertile period, the girl's voice can literally make a boy's skin tingle.

In boys, broad shoulders and a clearly defined jawline can make hearts flutter, as can a low voice. These features are indicators of large amounts of the hormone testosterone in the blood. Most people like boys to have muscles, although you must not go too far. Action heroes in films often have very exaggerated muscles. Boys who take these idealized images seriously and spend a lot of time in the gym run a risk of 'bigorexia': concentrating so much on building up muscles that it gets out of control and they become depressed. Anyway, what is considered beautiful is relative and it changes over time. For example, thanks to K-pop (a South Korean music style), softer, more 'feminine' features are now found attractive in men and boys.

NICE = ATTRACTIVE

People often find symmetrical faces more attractive in both boys and girls. A symmetrical face shows that a person experienced little external stress as a baby in the womb. The face also reveals a lot about someone's personality. Both boys and girls find the faces of people who are nice more attractive.

fig. 1 Flirting.

PHEROMONES

Appearance isn't everything: smells matter too. Everyone has their own special body smell that is made up of hundreds of pheromones (aromas). These aromas are made in the testicles or ovaries, for example. Your aromas depend in part on your immune system. Girls feel more attracted to boys who have different DNA for the immune system than they do. Unless they are on the pill: girls on the pill are more likely to fall for someone with the same immune system as them then. So the pill can help you to fall in love.

SELF-CONFIDENCE

If you want to appear attractive, you can start by eating healthily because that often gives you a healthy appearance. You are also more attractive if you seem self-confident. Don't watch porn videos as they are bad for your self-confidence. They give an unrealistic impression of relationships and can be addictive. And you are then less likely to fall for real people.

You can also apply a fragrance. Some adverts say particular male deodorants are date magnets but that is not true. Girls don't fall for boys because their deodorant smells so nice. But the boys smell their own deodorant and feel more self-confident as a result; the girls respond to that and think the boys are more handsome. Boys should not use too much deodorant because then the girls won't be able to smell their natural odour. Both boys and girls should not forget to laugh now and then. Scientists say that is when you are at your most attractive.

Source: after 'The Strange Science Of Sexual Attraction', Carolyn Gregoire, huffpost.com, 14 July 2015.

EXERCISES

1

a What are the main determinants of physical attraction?
primary / *secondary* sexual characteristics

b Are broad shoulders in boys mainly caused by the structure of the skeleton or by big muscles? Explain your answer.

c Which bones are responsible for broad hips in girls?

d The hormone oestradiol determines the ratio of the hips to the waist in girls. This same hormone plays a role in pregnancy.
Explain why a value of 0.7 for the ratio of the waist to the hips is an indicator of fertility from a biological perspective.

e Explain what is meant by "softer, more 'feminine' features" in a man.

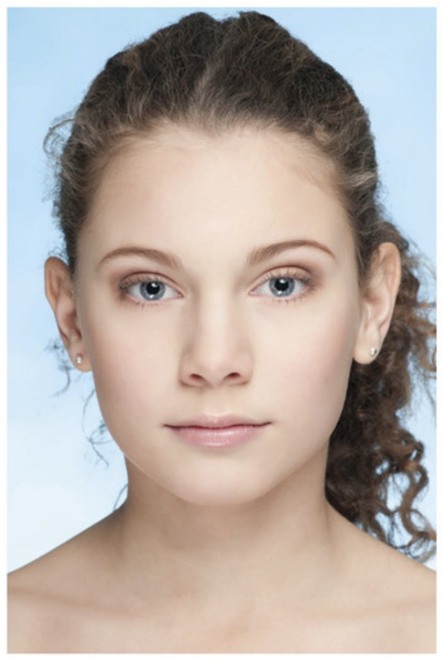
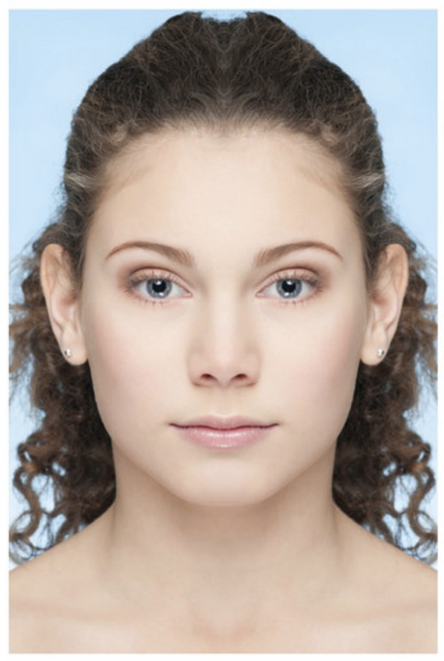
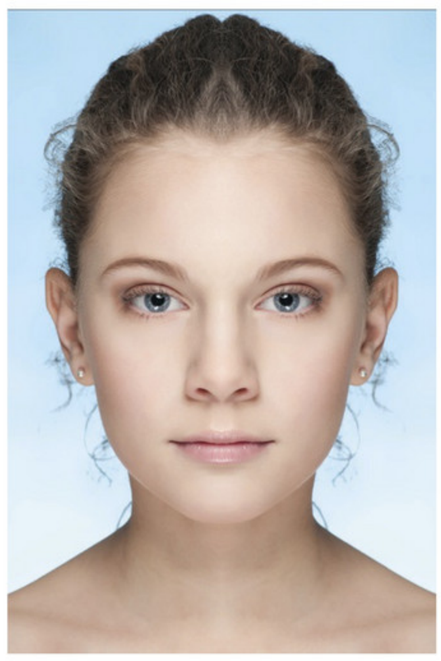
2

a What do you personally find attractive in others? Write down one physical characteristic, one mental characteristic and one social characteristic.

b Look at your answers to Question (a).
Which of these characteristics could change during the various stages of life?

c Have a look at figure 2.
Which face do you find the most attractive? Is that because of the symmetry of the face or because of other characteristics?

fig. 2 Which picture of this girl do you find most attractive?

3

a The hormone oestradiol gives girls a slightly redder face.
What influence does oestradiol have on the blood circulatory system?

b Imagine a girl has her period from 4 to 7 May.
On which days is her face particularly attractive due to hormones?

c Girls can use make-up to emphasize or hide the particular physical characteristics of the fertile period.
Give an example of both.

4

a When a woman is at her most fertile, her voice can make a man's skin tingle.
Is this a voluntary response or a reflex?

b Describe the route from stimulus to tingling skin.

c Do you consciously think of reproduction when you find someone attractive?

d Could reproduction play a role unconsciously when you find someone attractive?

e Porn gives a distorted impression of bodies.
The stimuli are *stronger* / *weaker* than in real people, and as a result you find real people *more* / *less* interesting.

5

a Pheromones are aromas that are sent to the person's surroundings rather than their organs.
Pheromones *can* / *cannot* be made by an endocrine gland. They *are* / *are not* hormones.

b A symmetrical face is an indicator of low stress when the person was a foetus in the womb.
Which hormone can get into the baby's blood via the umbilical cord if the mother is stressed?

7 More contraceptives

LEARNING OBJECTIVE

4.7.15 You can name other ways of preventing pregnancy.

TAXONOMY	LEARNING OBJECTIVE AND EXERCISES
	4.7.15
Remembering	
Understanding	1
Using	2
Analysing	

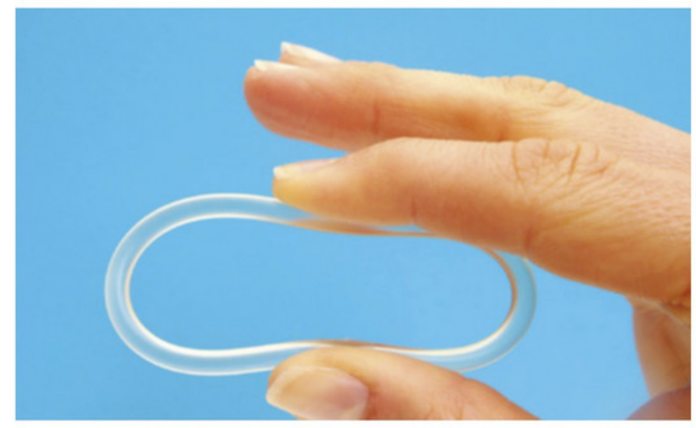
As well as the pill and the condom, there are various other ways of preventing pregnancy (see figure 1). Most are used by the woman.

HORMONES

The **NuvaRing** is a plastic ring that contains the same hormones as the pill (see figure 2.1). The woman inserts the NuvaRing in her vagina. She keeps the ring in the vagina the whole time for three weeks, followed by one week without. When used properly, the NuvaRing is just as reliable as the pill.
The contraceptive injection, the contraceptive patch (see figure 2.2) and the contraceptive implant also contain the same hormones as the pill and are very reliable.
The **contraceptive injection** involves a woman being injected every three months with a hormone that inhibits ovulation. Menstruation is lighter and can stop altogether. If a woman stops the contraceptive injection, it can take two years for menstruation to return.
A **contraceptive patch** is worn on the skin for three weeks and replaced every week. Then there is a week without the patch.
The **contraceptive implant** is about the same size as a matchstick and is inserted under the skin in the upper arm. The implant releases a small amount of hormone into the body every day. The implant can stay there for three years.

fig. 1 Various contraceptives.

fig. 2



1 NuvaRing

2 contraceptive patch

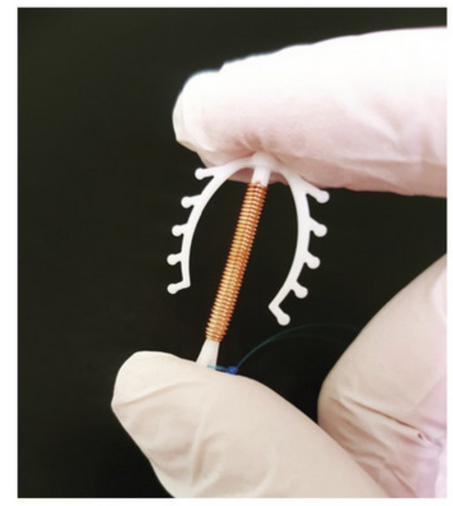
OTHER METHODS

The **female condom** is a special kind of condom that is inserted in the vagina (see figure 3). It can be inserted several hours before sex so there is no need to interrupt the sex. Each female condom must only be used once. The female condom is reliable and also protects the woman from STIs.
The **IUD** – commonly called the **coil** (see figure 4) – is inserted in the womb by a doctor. There are two kinds of coil. A **hormonal coil** (see figure 4.1) releases small amounts of hormone every day. The effect of the hormones is to inhibit fertilization and implantation. The effect of the hormonal coil wears off after five years and it has to be replaced.
The **copper coil** is wrapped in a copper thread (see figure 4.2). A copper coil can remain in the womb for a long time; ten years is no exception. In the womb, the copper coil causes a reaction that affects sperm cells and inhibits implantation.
IUDs are highly reliable.

fig. 3 Female condom.

fig. 4 IUDs.

1 hormonal coil

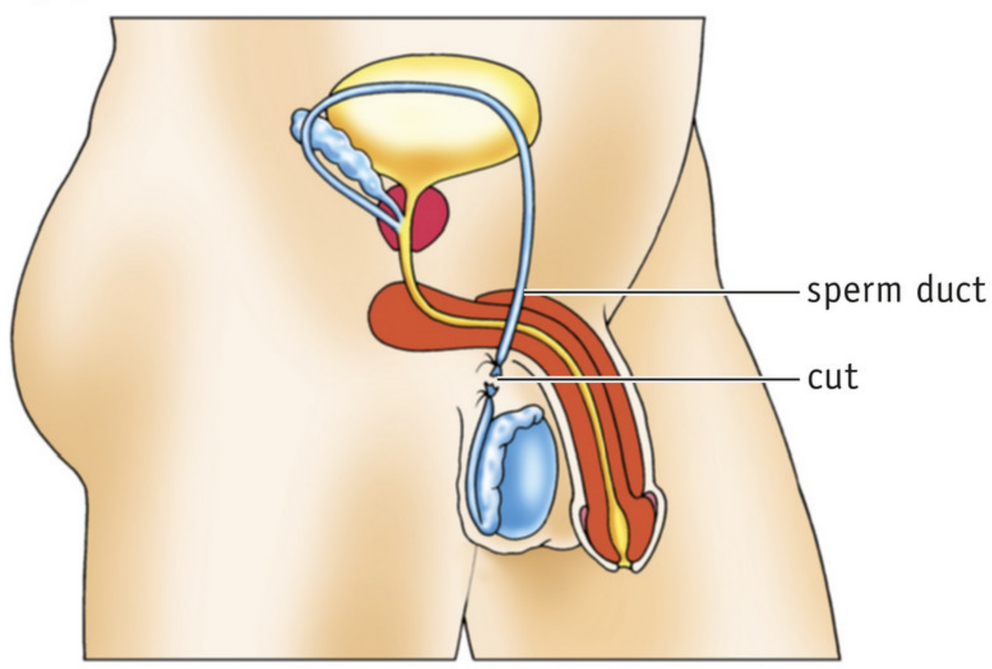


2 copper coil

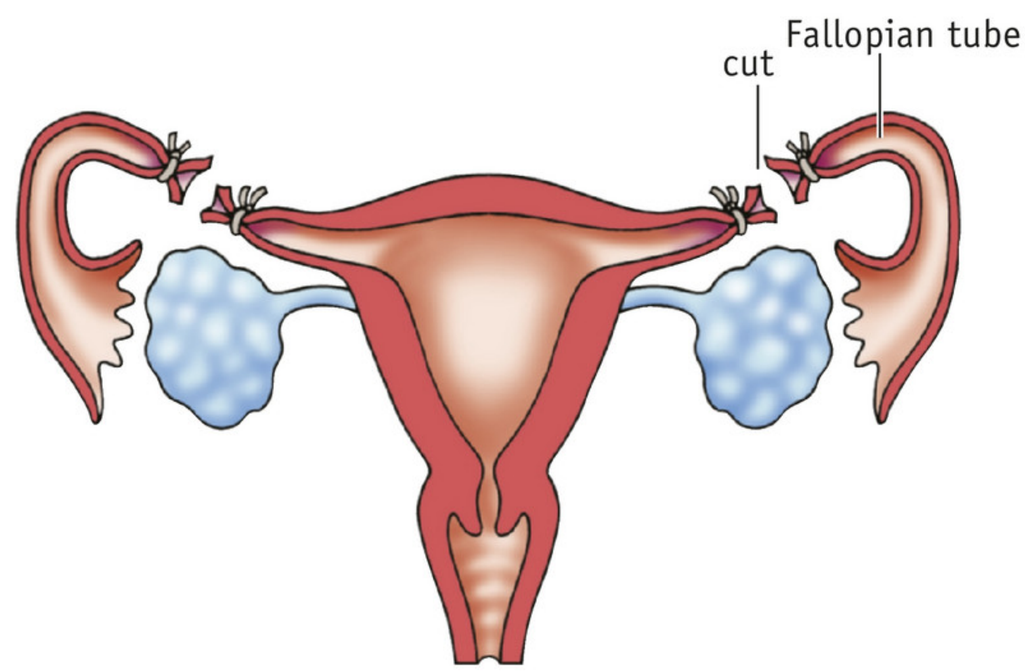
STERILIZATION

Sterilization is a minor operation that makes a man or woman infertile. In men, both sperm ducts are sealed off (see figure 5.1). The production of sperm cells continues as normal. There is no change either in the amount of fluid released in an ejaculation. But the sperm cells that are produced can no longer leave the body. They are broken down in the epididymis and the sperm duct. In women, the Fallopian tubes are sealed off, so that the ova can no longer come into contact with sperm cells (see figure 5.2).

fig. 5 Sterilization.



1 of a man



2 of a woman

EXERCISES

1 The table below lists some details of various methods of contraception. Complete the rest of the table.

Method of contraception	How it works	Other benefits	Other disadvantages
NuvaRing			Can have side effects, for example nausea and headaches, and a small risk of thrombosis.
Female condom			Each one can only be used once.
Contraceptive injection			Menstruation may be irregular or absent and it may take a long time after stopping before menstruation restarts.
Coil	Changes the womb lining so that implantation can no longer occur.		
Sterilization		Only has to be done once; all the sexual functions continue as normal.	Difficult to reverse.

2 Women can choose to use a female condom.
Write down three reasons why women might choose the female condom as a contraceptive.

Go to the *Flash cards*.

8 The birth

LEARNING OBJECTIVE

4.8.16 You can describe how childbirth progresses.

TAXONOMY	LEARNING OBJECTIVE AND EXERCISES
	4.8.16
Remembering	
Understanding	1, 2
Using	3, 4, 5
Analysing	

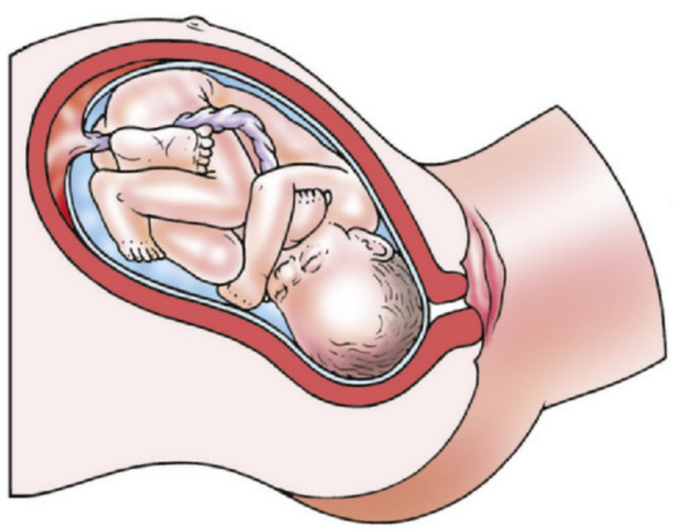
After a pregnancy of nine months, the baby is born. The birth takes place in various phases.

CHILDBIRTH

The first sign that the **childbirth** is starting are usually **contractions**. These are contractions of the muscles in the uterine wall, with intervals in between. During the contractions, the cervix (mouth of the womb) becomes wider (see figure 1). This is called **dilation**. The amniotic sac generally ruptures ('the waters break'), and the amniotic fluid flows out of the vagina. It may take anything up to twenty hours for the dilation to be sufficient for the baby's head to pass through.

This is then followed by the **delivery** (see figure 2). The contractions become increasingly powerful and the muscles in the abdominal wall start contracting too. These more powerful **delivery contractions** push the baby out. The delivery may take anything from a few seconds to a couple of hours.

fig. 1 Dilation.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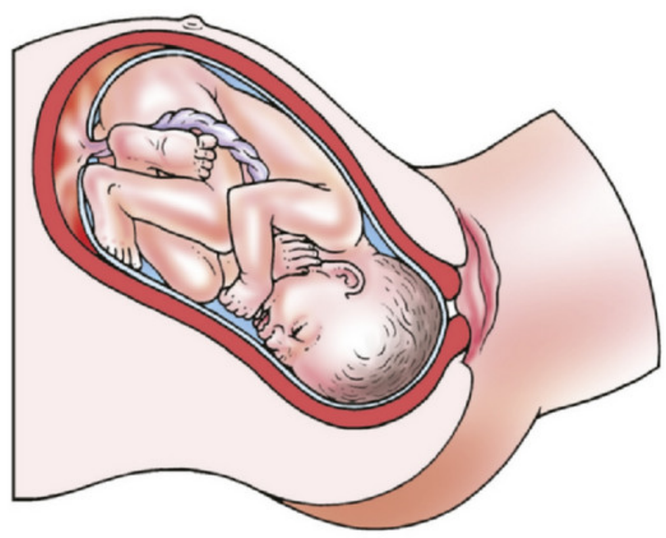
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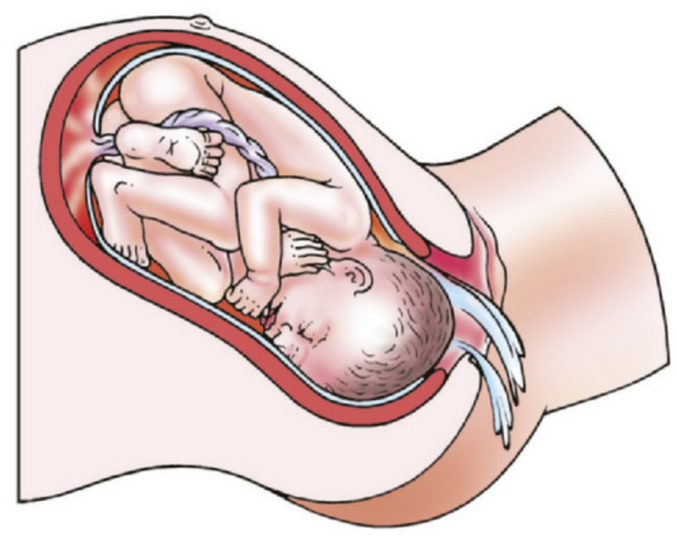
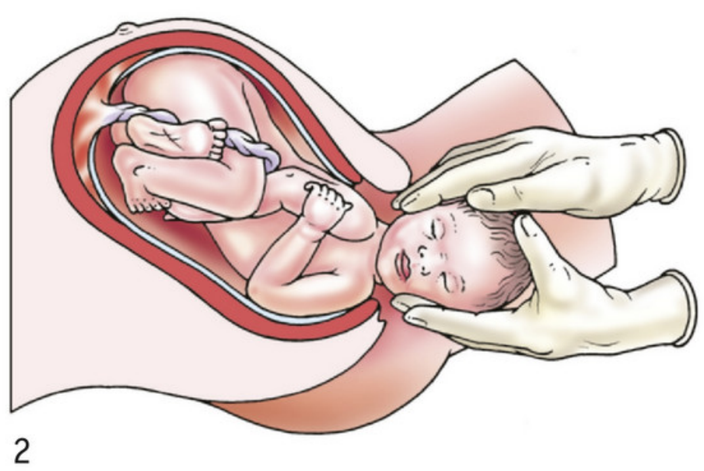

3

fig. 2 Delivery.

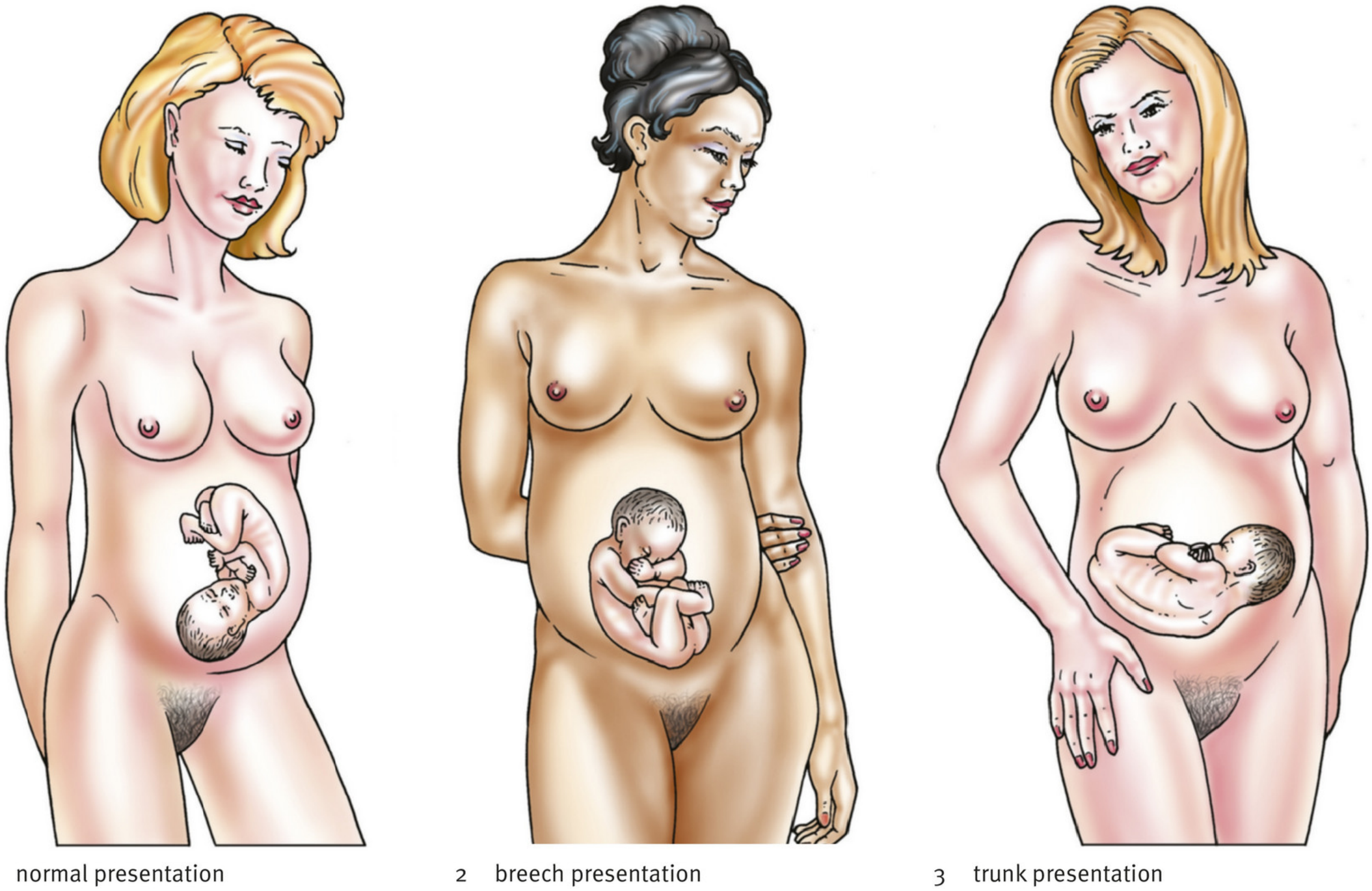
1


2

3

In a normal birth, the head appears first (see figure 3.1). In a **breech presentation** (see figure 3.2), the rump or a foot will come out first. In a **trunk presentation** (see figure 3.3) the baby cannot be born vaginally and it will be born in a surgical procedure to cut through the abdominal wall (**caesarean** section). The child will also often be born by caesarean in a breech presentation. A trunk presentation is rare.

fig. 3 The position in the mother's abdomen.



1 normal presentation 2 breech presentation 3 trunk presentation

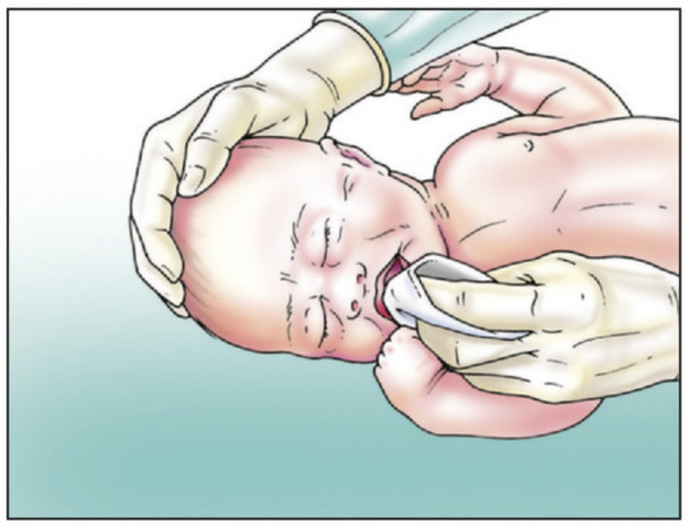
AFTER THE BIRTH

After the birth, residues of mucus are removed from the baby's mouth and airways (see figure 4.1). The umbilical cord is then clamped off and cut (see figure 4.2). The baby will usually start to cry straight away. That is a good sign, as it means the baby has started breathing.

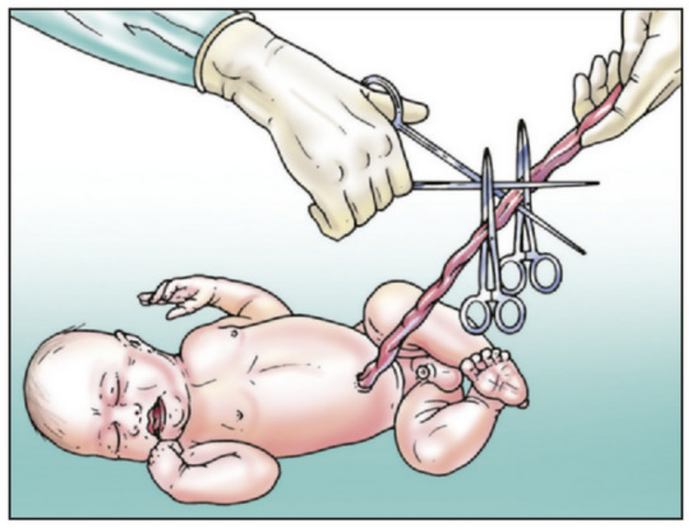
The part of the umbilical cord that is attached to the baby dries out over the course of about a week and then falls off. This leaves a kind of scar on the baby's belly, the **navel** (belly button).

The birth is not completely finished once the baby has been delivered. Contractions of the uterine wall release the placenta and the remains of the umbilical cord and the amniotic sac. These are then expelled about a quarter of an hour after the delivery of the baby (see figure 4.3). This is called the **afterbirth**. The afterbirth can be speeded up by an injection of a hormone. The midwife or doctor checks that the whole afterbirth has come out.

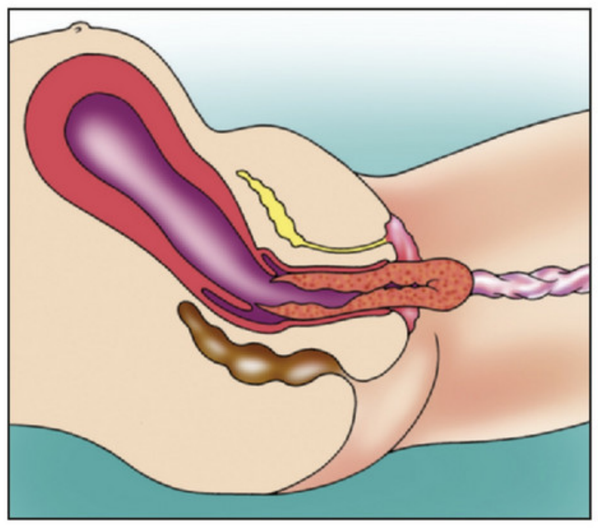
fig. 4 After the birth.



1 Mucus residues are removed from the baby's mouth.



2 The umbilical cord is clamped and cut.



3 afterbirth

EXERCISES

1 Complete the sentences. Use the words *uterine wall – abdominal wall – head – caesarean – afterbirth – navel – umbilical cord – dilation – delivery contractions – placenta – mucus – breech presentation – delivery – amniotic sac – amniotic fluid – contractions*.

During ....., the lower part of the womb becomes wider.

During this phase, ... can occur. These are contractions of the muscles in the wall of the womb that take place at intervals.

The ..... may break during this stage (the 'waters breaking'), and the ..... then flows out of the vagina.

The phase that follows is called the ..... The muscles of the ..... also contract in this phase of labour and there will then be ..... These push the baby out. In a normal birth, the ..... appears first.

In a ....., the rump or a foot will come out first.

A transverse presentation (trunk presentation) means that the baby will be born by ..... section. After the birth, the ..... has to be removed from the airways. The ..... is clamped off and cut. The end of it that is attached to the baby dries out and falls off. The scar that this leaves is called the ..... Contractions of the ..... detach the ..... and the remains of the umbilical cord and the amniotic sac. This is referred to as the .....

2 Read the text 'Obstetrician' in figure 5.

a Anne, the obstetrician, says that Mrs Williams is allowed to push actively with the contractions.
What phase of the birth is then starting? *contractions* / *dilation* / *delivery* / *afterbirth*

b Which two groups of muscles contract together during the contractions?

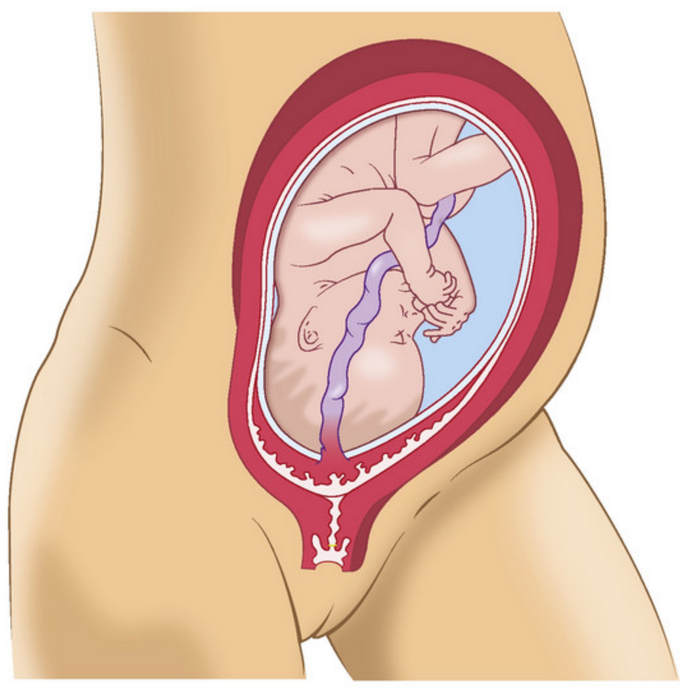
fig. 5

Obstetrician

Anne works as an obstetrician. She helps women during pregnancy, childbirth and the first few hours after the birth. "To give you an impression of my work, I'll tell you quickly about the last birth. I went to see Mrs Williams at two o'clock. She was having strong contractions and the waters had already broken naturally. I watched to see how she was coping with the contractions, how often they were coming and how strong they were. Then I felt to see what position the baby was in, listened to its heart and did an internal examination to assess Mrs Williams's dilation. She was fully dilated (10 cm). I got everything ready and called the maternity care service. When the delivery contractions came, I told Mrs Williams that she should push too. After 45 minutes, she had a lovely son. The father cut the umbilical cord and I examined the baby: a healthy little boy. Once the afterbirth has been expelled, it was time for the traditional treats. In the meantime, I completed all the forms and kept a close eye on both mother and child. This was a quick birth.
Sometimes it won't go so smoothly. For example, if there is a breech birth or if the baby is distressed or if there is faecal matter in the amniotic fluid. The baby is then usually born in the hospital. For many women, pregnancy is an exciting but nevertheless enjoyable time, despite the fact that they can get all kinds of symptoms because of the pregnancy, and despite the birth being very painful, of course. I find it very satisfying that I can do something for these women at such a special time."

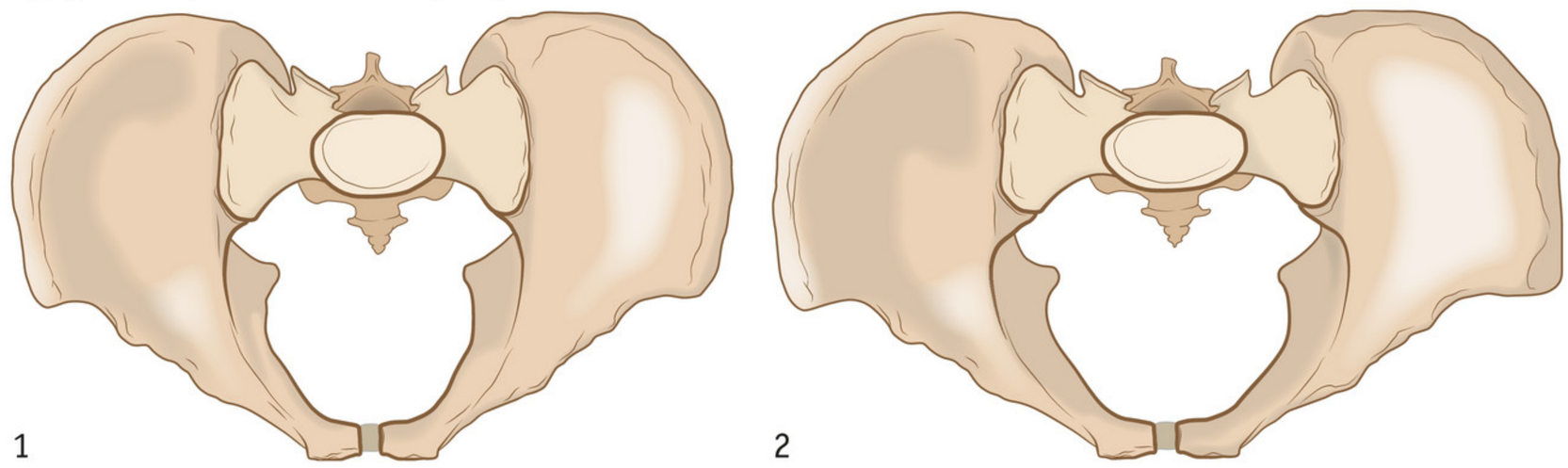
3 How will the baby in figure 6 be born: vaginally or by caesarean? Explain your answer.

fig. 6



4 Figure 7 shows two drawings of women's pelvises.
Which woman is more likely to need a caesarean: woman 1 or woman 2? Explain your answer.

fig. 7 The pelvises of two pregnant women.



5 Read the text 'Lame excuse really was an emergency childbirth' in figure 8.

a Which phase of the birth had started shortly before the man and woman drove off from home?
dilation / delivery / afterbirth

b Which stage of the birth had started when they were stopped by the police?
dilation / delivery / afterbirth

c Which stage of the birth started in the hospital's delivery room?
dilation / delivery / afterbirth

fig. 8

Lame excuse really was an emergency childbirth

EINDHOVEN – A car driver called out of the car window during a traffic check that his wife was about to give birth and then disappeared at high speed. The policemen had heard that one a few times before and didn't take the man at his word. After a chase by the police, the man turned out genuinely to have an expectant mother in the car with him. According to a police spokeswoman, the baby's head was already visible when the man was forced to stop. When it turned out that there really was a woman in the late stages of labour, the couple were escorted by the police to hospital. The delivery room was already prepared. A short while later, the woman had produced a healthy son. The woman turned out to have started getting contractions suddenly at home, and so the couple set off for the hospital double quick.

Go to the *Flash cards*.

Learning how to do research

1 PROCESSING RESULTS DIGITALLY

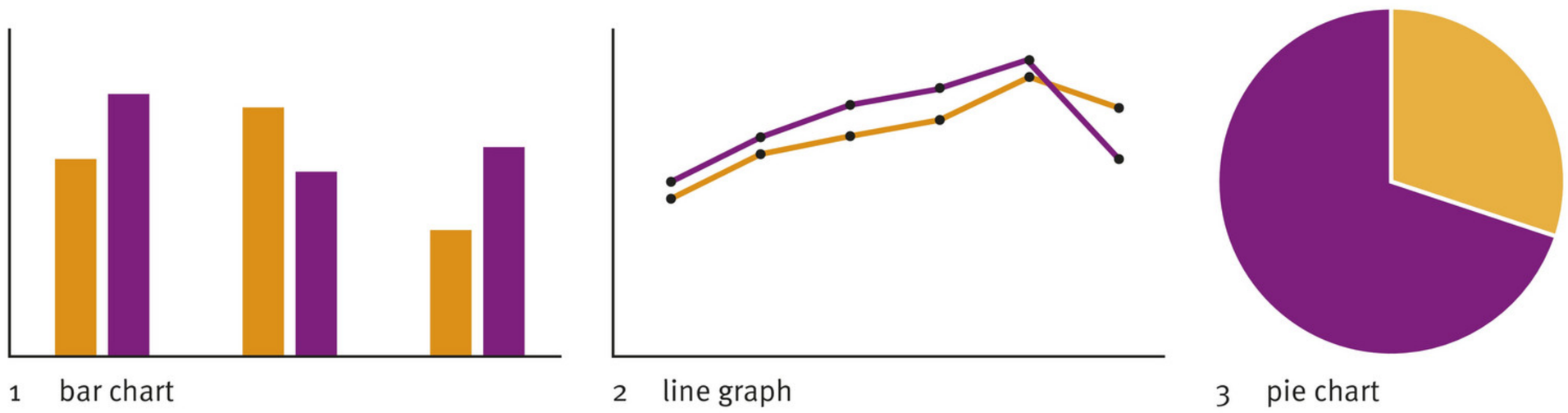
► Basics 5 | ► Learning objective 4.0.17

You can use a table or chart to give a clear overview of the results of a study. Use a chart when you have a lot of results or have measured a lot of different factors. Three types of chart are the bar chart, line chart and pie chart (see figure 1).

You can make charts on a computer. Using a computer to record and process your results has various advantages:

- You are less likely to lose your results than when they are on bits of paper.
- The computer can make the charts for you.
- The charts look neater.
- You can easily share the results and charts with others.

fig. 1 Three types of chart (schematic).



1 bar chart 2 line graph 3 pie chart

PROGRAMS FOR YOUR RESULTS

Various programs can be used to make tables and charts. The most commonly used program is Microsoft Excel (see figures 2.1 and 3). Most people have Microsoft Excel on their computer or laptop. Google Sheets is also popular (see figure 2.2). You need the Internet for that particular program. The advantage of Google Sheets is that several people can work on a document at the same time. People with an Apple computer or laptop can use the Numbers program (see figure 2.3). This program is available on all Apple computers or laptops.

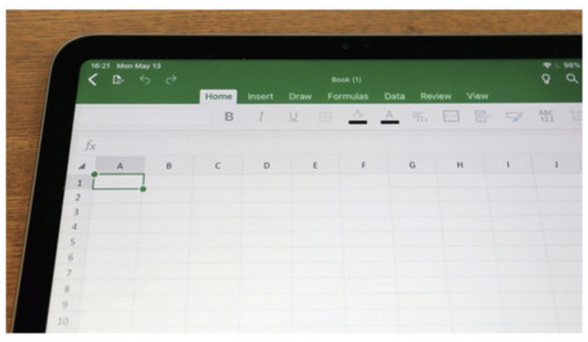
fig. 2 Apps for making tables and charts.

1 Microsoft Excel

2 Google Sheets

3 Numbers

fig. 3 A worksheet in Excel.



MAKING A CHART

To make a chart on the computer, first you create a table in the program. Enter the data into the table that you want to show in the chart. Then select the table. Choose the type of chart you want to make. The program will automatically create that chart. You can then make changes to the chart. For example, you can change the colour, add texts to the axes or add a legend.

EXERCISES

1 Read the text 'Does the fertile period make people attractive?' in figure 4.
Biologists examined whether a woman's face becomes more attractive during her fertile period. Fiona draws the conclusion that you can tell from a woman's face when her fertile period is because women are usually considered more attractive during the fertile period.

a Is Fiona right? Explain your answer.

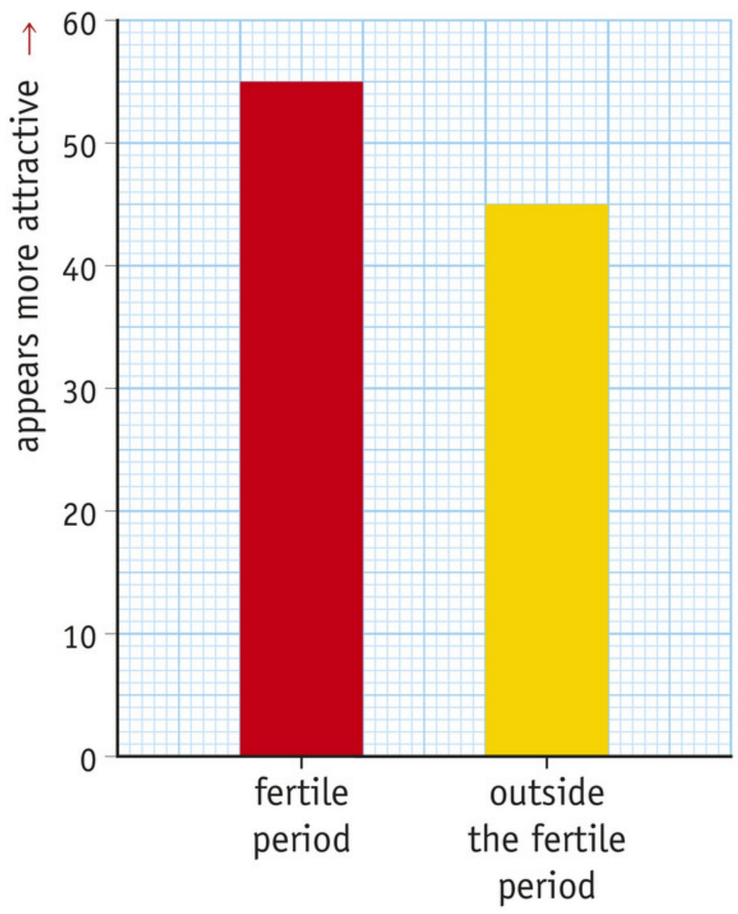
b Reproduce the bar chart shown in figure 4 in Excel (or another program).
Print the chart and keep it with this exercise.

c Because the results are shown in percentages, you can also make a pie chart. Turn the results into a pie chart in Excel (or another program). Make show the percentages are shown in the circle.
Print the chart and keep it with this exercise.

fig. 4

Does the fertile period make people attractive?

In many animals, the start of the female's fertile period can clearly be seen. In chimpanzees, for example, the sexual organs become swollen and redder (see photo). But that is not so clear in humans. Or maybe it is, just a little? Researchers at Newcastle University wondered whether the attractiveness of female faces might change during the menstrual cycle. Might the face of a woman be seen as more attractive during her fertile period?

RESEARCH	FERTILE PERIOD AND ATTRACTIVENESS
Research question	Does the face of a woman appear more attractive during her fertile period?
Hypothesis	The face of a woman is seen as more attractive during her fertile period.
Work plan	For 50 women aged between 19 and 33, two photos were taken: one during the days when they were fertile (or a couple of days before that) and one two weeks later. Then 250 people were asked which of the two photos they found more attractive.
Results	

2 Figure 5 shows a study of the number of people in the Netherlands who got tested for STIs.

a Why is the data in this table best shown as a line chart?

b Use the computer to make a line chart of the data in figure 5.

- Add a label to the *y*-axis.
- Make sure your chart has a legend.
- Print the chart and keep it with this exercise.

c Two pupils draw a conclusion from the results in figure 5.
Pupil 1: The number of heterosexual men who get an STI test is higher than the number of homosexual men who get an STI test.
Pupil 2: In 2018, the number of women who got an STI test was higher than the number of men who got an STI test.
For each pupil, write down whether they are *correct* or *wrong* and explain why. For Pupil 2, do a calculation as well.

Pupil 1 is ..... because .....

.....

.....

.....

Pupil 2 is ..... because .....

.....

.....

fig. 5

RESEARCH	STI TESTS IN THE NETHERLANDS
Research question	How many people get tested for STIs in the Netherlands?
Work plan	Between 2014 and 2018, GPs and the Sexual Health Centres kept records of the number of people who got tested.
Results	

Year	Heterosexual men	Homosexual men	Women
2014	40,856	29,939	70,219
2015	35,719	34,442	65,991
2016	35,065	40,340	67,600
2017	35,242	45,553	69,375
2018	33,041	49,873	68,710

3 Figure 6 shows a study into the reliability of nine methods of contraception. The results are shown in a table.

a Use the computer to make a bar chart of the results.
If two numbers are shown, use the average.
Put the contraception methods on the *x*-axis. Put the Pearl index on the *y*-axis.
Label the *y*-axis as the 'Pearl index'. Add a legend to your chart.
Print the chart and keep it with this exercise.

fig. 6

RESEARCH	RELIABILITY OF NINE METHODS OF CONTRACEPTION
Research question	Which methods of contraception are reliable?
Work plan	For nine different methods of contraception, the number of pregnancies in a year among one hundred sexually active women of childbearing age was determined that occurred despite them using a particular method of birth control. The results are shown using the Pearl index (the pregnancy rate). The theoretical Pearl index shows the percentage of pregnancies if the method in question is used perfectly. In practice, however, errors are made in using them occasionally.
Results	

Method of contraception	Pearl index in theory	Pearl index in practice
1 Condom	2	5 to 12
2 The pill	2 to 3	5
3 Withdrawal method	1	12 to 38
4 Rhythm method	3.3	6-49
5 NuvaRing	0.4	0.5 to 2
6 Contraceptive injection	0.1	0.5
7 Female condom	2.6	3 to 5
8 IUD	0.2	1 to 3
9 Sterilization	0.25	0.5

b The table shows various methods of contraception classified according to their reliability.
Draw a conclusion from this study by completing the rest of the table.

Average Pearl index in practice	Evaluation	Contraception
0–3	Very reliable	
3 to 5	Reasonably reliable	
Greater than 5	Unreliable	

c What is the advantage of the bar chart you made compared with the table in figure 5?

d The study shows that the condom and the female condom are not the most reliable methods of contraception in practice.
Explain why it may still be a good idea to choose one of these contraceptive methods.

e One third of women on the pill forget to take the pill regularly and on time.
Will this make the Pearl index for the pill higher or lower in practice? Explain your answer.

Practical activities

1 SPERM CELLS

► Basics 3 | ► Learning objective 4.3.6

20-30 minutes

WHAT ARE YOU GOING TO DO?

In this experiment, you will be examining a specimen of sperm cells. You will make a drawing of one sperm cell.

WHAT DO YOU NEED?

- ☐ a microscope
- ☐ a specimen slide of sperm cells
- ☐ drawing materials

WORKING METHOD

- Examine the specimen under the microscope at a magnification of 40×. Find a section where you can see one sperm cell clearly.
- Examine the sperm cell at a magnification of 400×.
- Make a drawing of the sperm cell. Label the following parts: *head – flagellum*.

2 EGG CELLS

► Basics 3 | ► Learning objective 4.3.6

20-30 minutes

WHAT ARE YOU GOING TO DO?

In this experiment, you will be examining a specimen of an ovary. This ovary contains egg cells (ova). You will make a drawing of one egg cell.

WHAT DO YOU NEED?

- ☐ a microscope
- ☐ a ready-made specimen slide of an ovary with egg cells
- ☐ drawing materials

WORKING METHOD

- Examine the specimen under the microscope at a magnification of 40×. Find a section where you can see one egg cell clearly.
- Examine the egg cell at a magnification of 400×.
- Make a drawing of the egg cell.

3 PUTTING ON A CONDOM

► Basics 5 | ► Learning objectives 4.5.10 and 4.5.11

15-25 minutes

WHAT ARE YOU GOING TO DO?

In this demonstration experiment, your teacher will show you how to put a condom on a plastic penis. The teacher will also show you what to do with the condom after ejaculation.

fig. 1

EXERCISE

1
- **a** Why should the penis be erect when you put the condom on?
- **b** Why do you need to be careful with sharp nails when putting on a condom?
- **c** Why should you hold firmly onto the bottom of the condom after ejaculation when withdrawing the penis?
- **d** Why should you check the condom before you throw it away?

4 STI TESTS

► Basics 5 | ► Learning objective 4.5.11

30-45 minutes

WHAT ARE YOU GOING TO DO?

In this experiment, you will investigate where you can get an STI test near you.

WHAT DO YOU NEED?

☐ a computer with an Internet connection

WORKING METHOD

- Search the Internet for at least three organizations that offer STI tests.
- For these three organizations, look for answers to the following questions:
  - How far is the organization from your home? Or is it online?
  - Can you do the test at home or at the organization's place?
  - Can you do the test anonymously?
  - Are the tests free?
  - Do you need to make an appointment for a test?
  - Is the test provided by professionals or volunteers?
- Put your answers in the table. If you come across other information that you want to remember, put that in the table too.
- Compare your table with the tables of some of your classmates. Perhaps a classmate found an organization that you don't have but that is located close to you. If so, add the information on that organization to your table.

Organization				
Distance from your home				
Test location				
Anonymous?				
Free?				
By appointment?				
Professionals or volunteers?				

Summary

BASICS 1

PUBERTY

1 **You can list primary and secondary sexual characteristics.**
- Sex: male or female.
  - Intersex: the sexual characteristics differ from the norm (male or female) and the body has both male and female characteristics.
- Sexual characteristics: the anatomical characteristics that define the sex.
- The primary sexual characteristics are present from birth.
  - in boys, they include the scrotum and penis
  - in girls, they include the labia and vagina
- Secondary sexual characteristics develop from about age ten.
  - in boys they include chest hair, beard growth, lower voice, muscular physique
  - in girls, they include breasts, wider hips, rounded body shapes

2 **You can describe the physical and emotional changes during puberty.**
- Physical changes during puberty.
  - Rapid growth happens (the 'growth spurt').
  - The reproductive organs start functioning.
  - The secondary sexual characteristics develop.
- Emotional changes during puberty.
  - More interest in other people.
  - Sometimes you fall in love with someone.
  - Sexuality starts to play an important role in life.
  - You start to act more independently from your parents.
  - You behave differently towards friends; friendships more often in groups.
  - Sometimes you feel angry, uncertain, lonely or sad.

BASICS 2

A WOMAN

3 **You can give the parts of the female reproductive system with their functions and characteristics.**
- Ovaries: these are where the development of the ova takes place.
  - The ova (or egg cells) are the female sex cells.
  - The ova start to develop in puberty under influence of hormones from the pituitary gland.
  - An ovum contains a lot of food reserves.
- Womb: this is where a fertilized egg cell can develop into a baby.
- Clitoris: sensitive to stimuli that give a nice feeling.
  - clitoral glans: sensitive 'bud' that is visible on the outside
  - clitoris hood: fold of skin around the clitoris glans
  - erectile tissues: fill with blood when the woman becomes sexually aroused
- Outer labia: thick folds of skin covered in hair.
- Inner labia: thin, smooth folds of skin.
  - Glands in the wall of the inner labia produce mucus during sexual arousal.
  - After puberty, the inner labia are larger than the outer labia in most women.
- Vagina: has a mucous lining on the inside.
  - There may be a ring of tissue, called the hymen, around the opening.
  - During menstruation, parts of the mucous lining and blood are discharged via the vagina.

4 You can describe the menstrual cycle.

- Ovulation: the term for when an ovum (egg cell) is released from an ovary.
  - After ovulation, an ovum lives for 12 to 24 hours.
  - If the ovum is fertilized, it can stay alive.
- Menstruation (having a period): monthly loss of the womb lining and blood.
- Menstrual cycle:
  - day 1: start of menstruation, womb lining is discharged
  - day 5 (roughly): womb lining starts to build up again
  - day 14 (roughly): ovulation
  - day 28: last day of the cycle, womb lining stops building up

BASICS 3

A MAN

5 You can give the parts of the male reproductive system with their functions and characteristics.

- Scrotum: fold of skin surrounding the testes and epididymis. The temperature is slightly lower than in the abdominal cavity, which is favourable for the development of sperm cells.
  - testes: produce sperm cells when stimulated by hormones from the pituitary gland
  - epididymis: for temporary storage of sperm cells
- Sperm ducts: for transporting sperm cells.
- Seminal vesicles: adds fluid and nutrients to the sperm cells.
- Prostate gland: adds fluid to the sperm cells.
- Urethra: transports urine and semen.
  - Semen consists of sperm cells and fluid from the seminal vesicles and the prostate gland.
- Penis: transports semen into the vagina.
  - erectile tissue: makes the penis become erect
  - glans penis: sensitive to stimuli that give a nice feeling
  - foreskin: fold of skin around the glans penis
- Sexual intercourse: the penis moves backwards and forwards in the woman's vagina.
  - During ejaculation, the semen comes out of the penis in spurts.

6 You can name the characteristics of sperm cells and egg cells.

Sperm cells	Egg cells
Very small	Relatively large
Can move (with the flagellum)	Cannot move
Do not have any food reserves	Contain a lot of stored food
Many millions per ejaculation	Usually just one ovum every four weeks

BASICS 4

SEX AND ALL THAT

7 You can describe what is meant by sexuality.

- Sexuality in humans: all the thoughts, feelings and acts that have to do with lust and arousal.
- Sexuality plays a role in:
  - intimacy (feeling close to one another in a romantic relationship)
  - libido (arousal, lust, pleasure)
  - reproduction (sexual intercourse, pregnancy)
- Orgasm (coming): a pleasant feeling from the stimulation of the glans (of the penis or clitoris).
  - The man has an ejaculation.
  - The woman's muscles contract around the vagina.
- Masturbation: giving yourself an orgasm.
- Porn (pornography): photos, films and text aimed at stimulating people sexually.
  - Pornography gives an unrealistic impression of sexuality.

8 You can describe how gender and sexual orientation can differ.

- Sexual orientation: the sex of the people you feel sexually attracted to.
  - heterosexual: you are attracted to people of the opposite sex
  - homosexual: you are attracted to people of the same sex
  - bisexual: you are attracted to people of either sex
  - asexual: you don't feel any sexual attraction
- Sex: anatomical sexual characteristics such as the penis or vulva.
- Gender: all the characteristics and behaviours that are usually considered masculine or feminine, e.g. being tough or being caring.
  - Gender identity: whether someone feels masculine, feminine or something in between.
  - Transgender: the sex (the body) doesn't match the gender identity (feeling).

9 You can describe how to safeguard and respect your wishes and limits in a sexual relationship.

- A healthy sexual relationship:
  - You both want it.
  - You are equals.
  - You have respect for one another.
  - You trust one another.
  - You tell one another honestly if you don't want to do something – or do want to.
- Wishes: things you enjoy and would like to do in terms of sex.
- Limits: things you don't want to do in terms of sex.
- Unacceptable sexual behaviour: someone makes sexual remarks or carries out sexual acts that you don't want.
  - Sexual harassment: someone touches you when you don't want them to.
  - Sexual violence: someone forces you to have sexual contact, e.g. sexual assault, rape, sexual acts in front of a webcam, grooming for prostitution ('loverboys').
  - People differ in what they see as unacceptable.
- Safeguarding and respecting wishes and limits:
  - Talk to each other about what you want and don't want.
  - Show non-verbally what you want and don't want.
  - Say clearly if you don't want to do something. Tell the other person to stop.
  - Don't do anything you don't want to and don't do anything the other person doesn't want.

BASICS 5

SAFE SEX

10 You can name some methods for contraception and explain how they work.

- Contraception: a woman determines (usually together with a man) whether she wants a baby or not.
- Unreliable methods:
  - rhythm method (no sexual intercourse during the fertile period, when ovulation takes place)
  - withdrawal method (the man takes his penis out of the vagina just before ejaculation)
- Condom: a latex sheath that is placed around the penis.
  - The sperm is collected in the condom and does not end up in the vagina.
  - Condoms also protect you from STIs.
- The pill: a pill that the woman takes every day at the same time.
  - The pill contains hormones that prevent ovulation from occurring.
  - The pill does not protect the woman from STIs.
- Emergency measures (for when something went wrong during sexual intercourse):
  - morning-after pill: can be taken up to three days after sexual intercourse
  - abortion: allowed up to the 24th week of pregnancy

11 You can name various STIs and explain how they can be prevented.

- STIs: sexually transmitted infections or venereal diseases.
  - Diseases that you can only get through intimate physical contact with an infected person.
- You can prevent STIs by using a condom.
- Chlamydia: the most widespread STI in the Netherlands.
  - The pathogen is a bacterium.
  - Disease symptoms: sometimes a (watery) discharge from the urethra or vagina, pain when urinating or blood loss from the vagina.
  - An untreated chlamydia infection can cause infertility in women.
- AIDS: the best-known STI.
  - The pathogen is a virus (HIV).
  - In AIDS patients, the immune system's ability to fight off all kinds of pathogens is affected. This means that there are no specific symptoms of illness for AIDS patients.
  - Infection can take place through blood, semen, vaginal fluid and pre-ejaculation fluid.
  - Someone who is seropositive has been infected with the AIDS virus but is not yet sick.
  - AIDS is treated with HIV inhibitors, which can slow the disease down but not cure it.
- Other STIs include genital warts and genital herpes.

BASICS 6

PREGNANCY

12 You can describe the fertilization of a human egg.

- Sperm cells move through the womb towards the Fallopian tubes.
- Fertilization: fusion of the nucleus of a sperm cell and the nucleus of an ovum.
  - Fertilization takes place in a Fallopian tube.
  - Fertilization is possible during the woman's fertile period (from approximately three days before ovulation to one day after ovulation).
  - An ovum can only be fertilized by a single sperm cell. Once the head of a sperm cell has entered the ovum, the outer layer of the ovum becomes impenetrable.
- A fertilized ovum divides a number of times. The cluster of cells that this produces is carried to the womb.

13 You can describe how a pregnancy progresses.

- Implantation: the cluster of cells attaches itself to the womb lining.
  - That cluster of cells grows to become an embryo. The embryo is called a foetus from the eighth week onwards.
  - During the first weeks of the pregnancy, the womb lining provides the nutrients. Then the placenta develops in the womb wall.
  - The woman doesn't menstruate during pregnancy.
- Placenta: part of the womb lining in which blood from the blood vessels of the embryo flows very close to the mother's blood.
  - The blood of the mother stays separated from the blood of the embryo.
  - Oxygen and nutrients cross from the blood of the mother to the blood of the embryo.
  - Waste products cross from the blood of the embryo back to the blood of the mother.
- Umbilical cord: connects the embryo to the placenta.
  - Blood flows through it from the embryo to the placenta and back.
- Two amniotic sacs and amniotic fluid: protect the embryo against knocks, dehydration and temperature changes.
  - The embryo can move easily in the amniotic fluid.

14 You can explain what a prenatal testing is and give some examples.

- Prenatal testing ('before the birth'): tests during pregnancy.
  - To investigate whether the mother has a relatively high risk of a baby with a congenital abnormality.
  - To determine the sex of the foetus.
- Ultrasound scan: sound waves are used to make a picture of the foetus in the womb.
  - After about 10 weeks: to determine how long exactly the woman has been pregnant.
  - After about 20 weeks: to detect abnormalities in the development of the foetus. It is also possible to see the sex of the foetus.
- Combined test: blood test and nuchal fold scan.
  - Blood test: a blood sample is taken from the mother and tested.
  - Nuchal fold scan: in the ultrasound scan, the baby's nuchal fold is measured.
- NIPT: non-invasive prenatal test.
  - A blood sample is taken from the mother and tested. The blood contains some DNA from the placenta. This is nearly always the same DNA as the baby's DNA.
  - The blood test may show there is an increased risk of a baby with a congenital abnormality.

EXTRA 7

MORE CONTRACEPTIVES

15 You can name other ways of preventing pregnancy.

- NuvaRing, contraceptive patch, contraceptive implant, contraceptive injection.
  - Hormones prevent ovulation from occurring.
  - As reliable as the pill when used properly.
- Female condom: is inserted in the vagina before sex.
  - The female condom is reliable.
  - The condom also protects you from STIs.
- Coil (IUD): is inserted in the womb.
  - It can prevent pregnancy for about five years.
  - Copper coil: affects sperm cells and prevents implantation.
  - Hormone coil: the hormones inhibit fertilization and implantation.
  - The IUD is highly reliable.
- Sterilization: the man or woman is made infertile.
  - The sperm ducts or Fallopian tubes are blocked off.
  - The procedure is very reliable.

EXTRA 8

THE BIRTH

16 You can describe the progress of childbirth.

- Childbirth starts with the contractions: the muscles of the uterine wall contract.
- Dilation: the uterine wall and the cervix become wider.
  - The amniotic sac breaks and the amniotic fluid flows out of the vagina.
- Delivery: powerful contractions push the baby out.
  - The head usually appears first.
- Childbirth:
  - Normal birth: the head appears first.
  - Breech presentation: the rump or a foot will come out first.
  - Trunk presentation: the baby can't be born vaginally and has to be born through a caesarean section.
- Afterbirth: the placenta and the remains of the umbilical cord and the amniotic sac are expelled.
- Navel: this is where the umbilical cord was attached to the foetus.

RESEARCH

LEARNING HOW TO DO RESEARCH & PRACTICAL ACTIVITIES

17 You can process results digitally in a table or chart.

Go to the *Flash cards* and the *Diagnostic test*.

5 Heredity and evolution

The DNA in the cell nucleus contains the information for all your hereditary characteristics. Parents pass their DNA on to their offspring. Small changes in DNA lead to species arising and disappearing.

BASICS

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TO FINISH

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Diagnostic test

1 Genotype and phenotype

LEARNING OBJECTIVES

5.1.1 You can describe what the genotype and phenotype are.

5.1.2 You can explain that cells only use the hereditary information that they need.

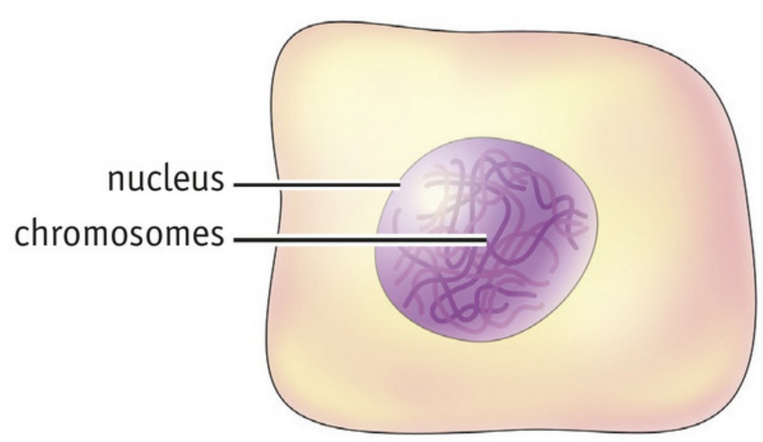
TAXONOMY	LEARNING OBJECTIVES AND EXERCISES	
	5.1.1	5.1.2
Remembering	2a	
Understanding	2bc, 3, 5	1, 4, 5
Using	6a, 7ab, 10ab	8, 9, 10ab
Analysing	6b, 7c, 10c	10c

Your body is made up of cells. Every cell has a nucleus that contains the information for your hereditary characteristics. You inherited that information from your parents.

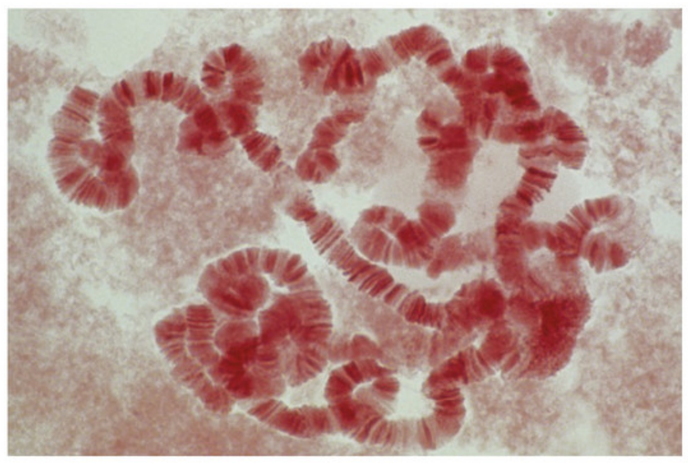
HEREDITARY INFORMATION

The cells that make up your body are called **body cells**. The nucleus of each body cell contains 46 chromosomes (see figure 1). **Chromosomes** are present in the nucleus as thin threads. They consist largely of the substance **DNA**. That substance stores the information for your hereditary characteristics.

fig. 1 Chromosomes.



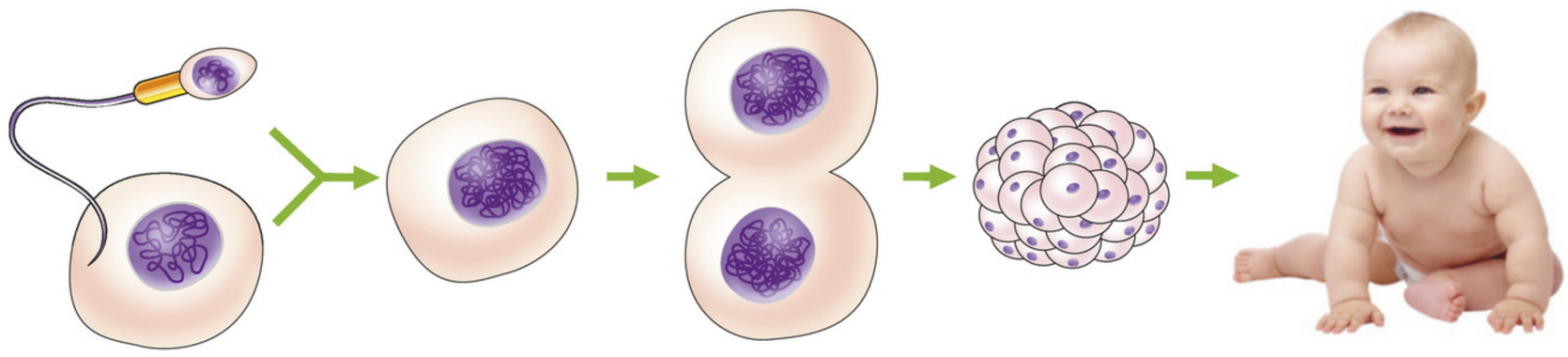
1 thin threads in the nucleus



2 microscope photo

All your body cells were created by cell division from a single, fertilized ovum. In each **cell division**, the chromosomes are copied first (see figure 2). Then the cell divides. Each **daughter cell** gets a complete set of chromosomes. That means that the nucleus of every body cell contains the same information. You inherit this information from your parents (half from your mother, half from your father).

fig. 2 Fertilization and cell division.



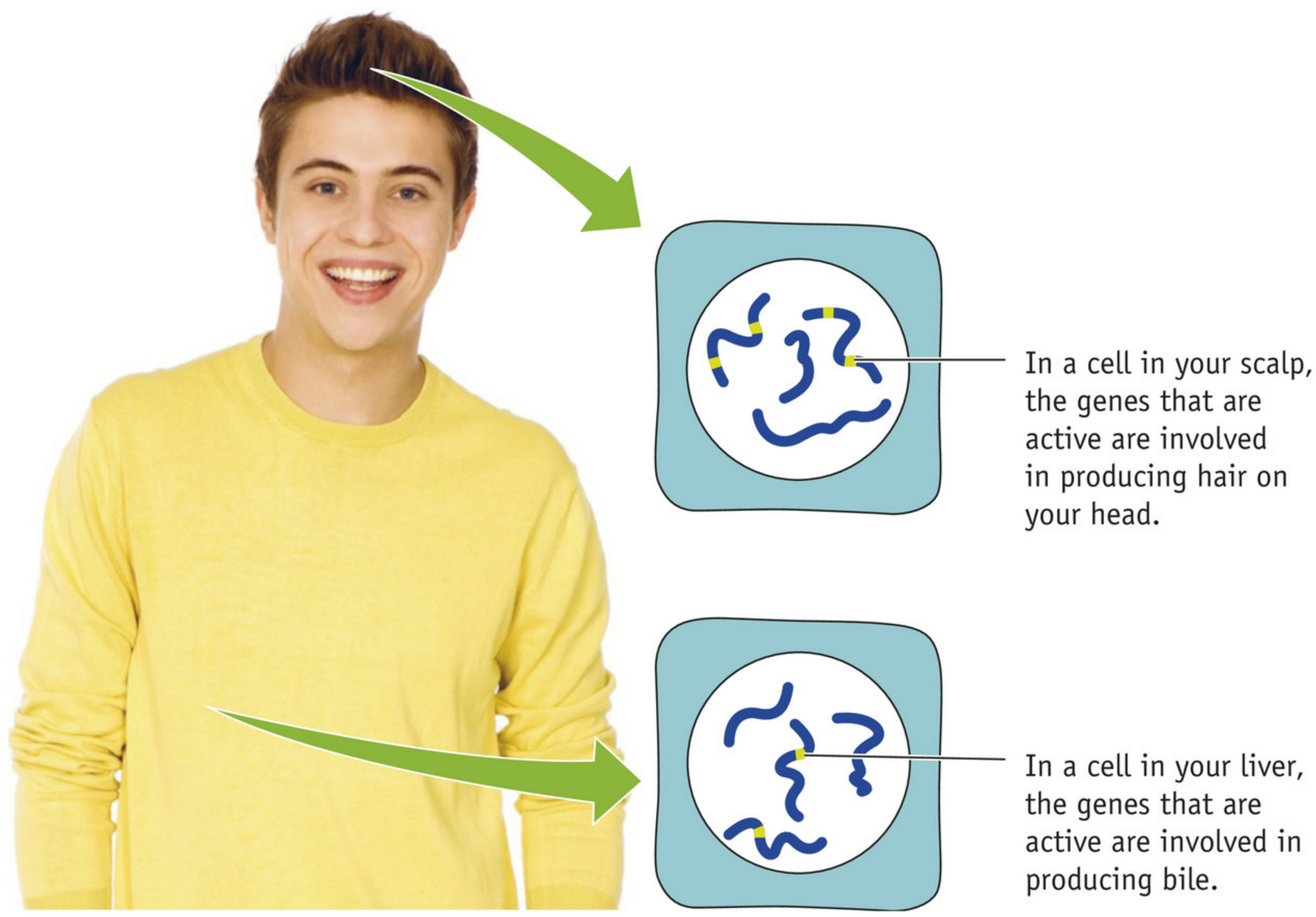
GENOTYPE

DNA contains information about thousands of characteristics. Each characteristic requires several pieces of DNA. The pieces of DNA that together contain the information for a characteristic are called a **gene**. The DNA in a single nucleus – all the genes taken together – contains the information for all your hereditary characteristics. This complete set of information is called the **genotype**. The genotype is created at the moment of fertilization.

A cell only uses the genes that it needs. The other genes are not active. Which genes are active depends on where the cell is in the body (see figure 3). In liver cells, for example, the genes that make the cell produce bile are active. The genes that create the hair on your head are not active there. In the skin cells on your scalp, it is the other way around: these cells do not make bile, but they do make hairs. So the genes for making head hair are active here.

If a gene is active, it may be just a little bit active or very active (switched on fully or just in part). For example, cells can make a lot of insulin or only a little depending on the amount of glucose in the blood. The genes for producing insulin can therefore be switched on 'loud' or 'quiet'.

fig. 3 Each body cell contains all the genes but not all genes are active.



PHENOTYPE

All the characteristics of an organism together are called the **phenotype**. The phenotype describes visible characteristics, such as eye colour, as well as ones that you cannot see, such as your blood pressure or the structure of your muscle cells.

The characteristics you get in life depend on your genotype, your lifestyle and your environment. If you are born with brown hair, that colour is caused by your genotype. But if you dye it purple, your hair looks different. Your phenotype has changed but your genotype will remain the same (see figure 4). The genotype still contains the information for brown hair. If you spend a lot of time in the sun in the summer, your hair will become lighter. That does not change the genotype either. If you don't do anything, the purple or light colour will grow out and your hair will be brown again.

Some characteristics are determined mainly by your genotype, such as the colour of your eyes. Other characteristics are determined only by your lifestyle or environment, such as a scar or tattoo. In most characteristics, both the genotype and the environment play a role. The phenotype of having a muscular build is created by a combination of genetic information (genotype) and training (lifestyle). The phenotype is the result of the genotype plus the influences from the environment.

fig. 4 Phenotype = genotype + environmental influences.

The phenotype changes...

...but the genotype doesn't.

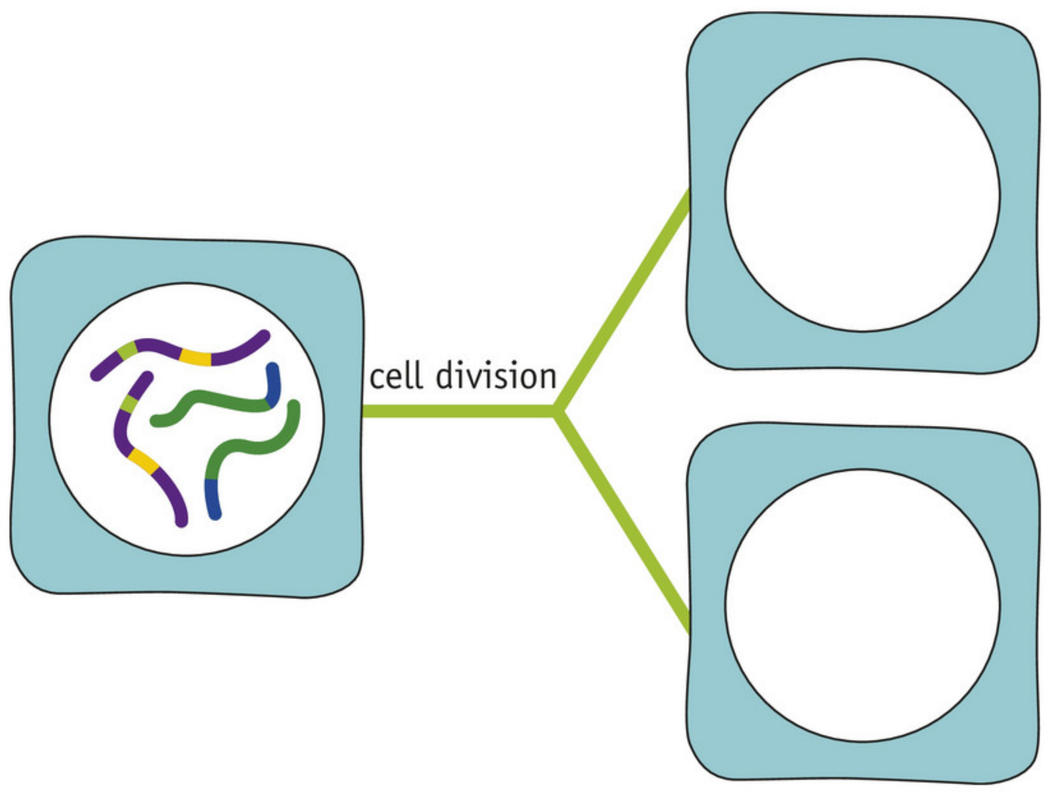
KNOWLEDGE

1 Figure 5 is a schematic drawing of a body cell. Chromosomes and genes have been drawn in the body cell. In cell division, two daughter cells are created.

a Draw the chromosomes with the genes in the daughter cells.

b
- Do all daughter cells have the same genotype after normal cell division? *yes / no*
- Do all daughter cells have the same genotype as the mother cell? *yes / no*

fig. 5 Cell division.



2

a
- All the characteristics of an organism together are called the .....
- The information for the genetic characteristics of an organism is called the .....

b Ed is a 15-year-old student.
Here are some of Ed's characteristics. For each of them, say whether or not it belongs to the phenotype.
- blond hair from birth *yes* / *no*
- large lung volume *yes* / *no*
- high blood pressure *yes* / *no*
- scar on the right knee *yes* / *no*
- tattoo on the forearm *yes* / *no*

c Suppose that you have the five characteristics listed here.
For each characteristic, say whether you have it because of your genotype, your lifestyle/environment, or both.

A You get very nervous before tests. ○
B You have a muscular body. ○
C You have a tattoo. ○
D You were born with curly hair. ○
E You can play the guitar well. ○

○ 1 genotype
○ 2 lifestyle/environment
○ 3 both

3

Renate takes part in the TV show *Extreme Makeover*, where she is treated by a plastic surgeon and beauticians. Figure 6 shows Renate before and after the makeover.

a Write down three visible characteristics that have not changed.

b Write down three visible characteristics that have changed.

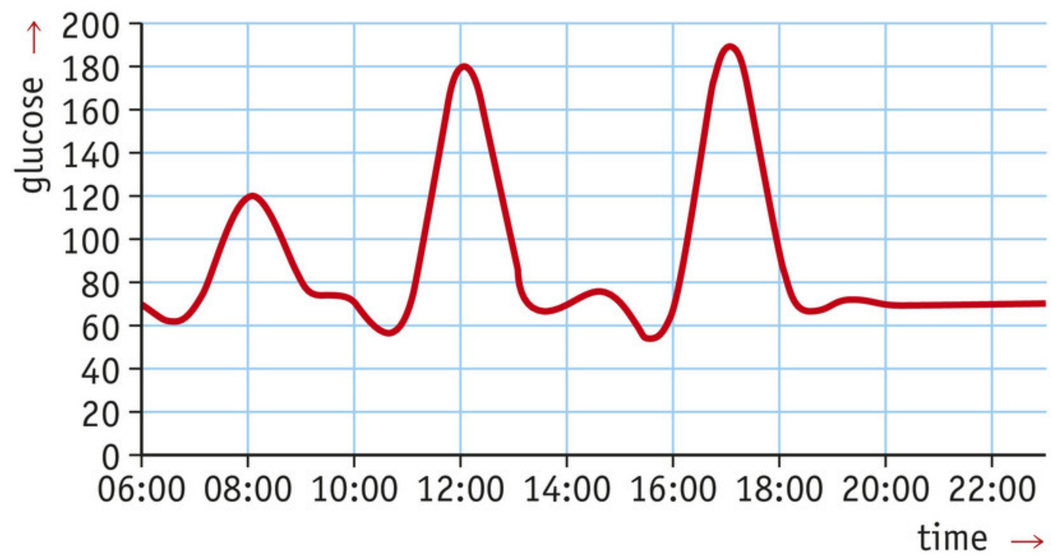
c Does Renate's phenotype change because of these treatments? What about the genotype?
- ○ A Only the phenotype changes.
- ○ B Only the genotype changes.
- ○ C The phenotype and genotype both change.
- ○ D Neither phenotype nor genotype changes.

fig. 6 Renate before and after treatment.

4 Insulin is made in the body. This hormone is needed to reduce the glucose level in the blood if it gets too high. Figure 7 shows how the glucose level in the blood changes over a day.
At which two times is the insulin production gene not very active?

- ☐ A 08:00
- ☐ B 10:00
- ☐ C 12:00
- ☐ D 16:00
- ☐ E 17:00

fig. 7 The glucose level in the blood.



5 **Summary**

Explain the following terms in your own words: chromosomes, cell division, DNA, phenotype, gene and genotype.

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INSIGHT

6 Figure 8 shows the metamorphosis of a frog.

a What remains the same at all stages of metamorphosis (2 to 8)?

- ○ A the phenotype
- ○ B the genotype
- ○ C neither
- ○ D both phenotype and genotype

b Explain how the phenotype can change during metamorphosis while the genotype remains the same.

fig. 8

7 Dafne Schippers is an elite athlete. She holds records for the 100-metre sprint. In 2015, she ran the distance in 10.81 s.

a Explain how Dafne's lifestyle plays a role in this achievement.

b Muscles consist of fast and slow-twitch muscle fibres. Fast-twitch muscle fibres are mainly used for short, explosive efforts. Slow-twitch muscle fibres are used for longer-term strength. As you grow older, the number of fast-twitch muscle fibres decreases. The number of slow-twitch muscle fibres increases.
How will this change affect Dafne's performance?

c Is the change in the number of muscle fibres due to a change in the genotype? Explain your answer.

8 UV radiation from the sun is harmful for your skin. Your skin is protected by melanin, a pigment that is produced in the skin and darkens it. Melanin also colours your hair and eyes. Being able to produce melanin is due to certain genes.

a When are these genes more active: in winter or summer? Explain your answer.

b On a sunny day, Joe and Jennifer go to the beach. At the end of the day, Joe's skin is a little tanned. Jennifer's skin has gone red.
Explain this using the genotypes.

c Are the genes for producing melanin as active in a muscle cell as in a skin cell?
Explain your answer.

+ 9 Marion Jones and Tim Montgomery were both elite athletes. That means that they had explosive muscle strength, lots of fast-twitch muscle fibres and good muscle metabolism. They had a son together. At birth, it was predicted that he would have a greater chance of becoming a top athlete than other children.

a Explain why their son had a greater chance of becoming a top athlete.

b Eventually, it turned out that Marion and Tim had both used doping to enhance their performance.
Explain why that means that their son has less chance of becoming a top athlete than was previously thought.

fig. 9 Marion Jones and Tim Montgomery.

HOW IT FITS TOGETHER the living world

LIVING IN THE MOUNTAINS

The air is thin at high altitudes. This means that the same volume of air contains less oxygen and breathing is therefore more difficult. You can get altitude sickness at heights of 2500 metres or more. The symptoms are headaches, dizziness and insomnia. The risk of altitude sickness makes climbing high mountains dangerous, so good preparation is needed.

One well-known mountain that is often climbed is Mount Everest. This mountain is in the Himalayas and it is 8848 metres high. Mountaineers are often accompanied by Sherpas during their climb. Sherpas are a Tibetan people who live in the mountain region that includes Mount Everest. In the old days, they made a living from cattle breeding and agriculture, and now they work as porters and mountain guides. They carry a lot of the mountaineers' luggage. Sherpas are well suited to life in the thin air.

fig. 10

10 Read the text 'Living in the mountains'.

Scientific research has shown that the genotype of Sherpas differs from the genotype of Europeans. Sherpas have a special version of a gene called Epas1. This gene plays a role in oxygen transport in the body: the oxygen transport is improved thanks to a higher concentration of haemoglobin in the red blood cells.

a Is the Epas1 gene not very active or very active in the high mountains? Explain your answer.

b The special version of the Epas1 gene is also called the 'super-athlete gene'. Explain why.

c Your body adapts to life in the high mountains in a different way than the bodies of Sherpas. When you stay in the mountains, your body produces more erythropoietin ('epo'), a substance that stimulates red blood cell production. After a few weeks in the high mountains, the number of red blood cells increases.
Does the number of red blood cells change because of a change in the genotype or a change in the environment? Explain your answer.

Go to the *Flash cards* and the *Test yourself* section.

2 Chromosomes

LEARNING OBJECTIVES

5.2.3 You can explain how each of the parents provides 50% of the chromosomes.
5.2.4 You can say how the sex of a human is determined by sex chromosomes.
5.2.5 You can explain how sexual reproduction causes variation in genotypes.

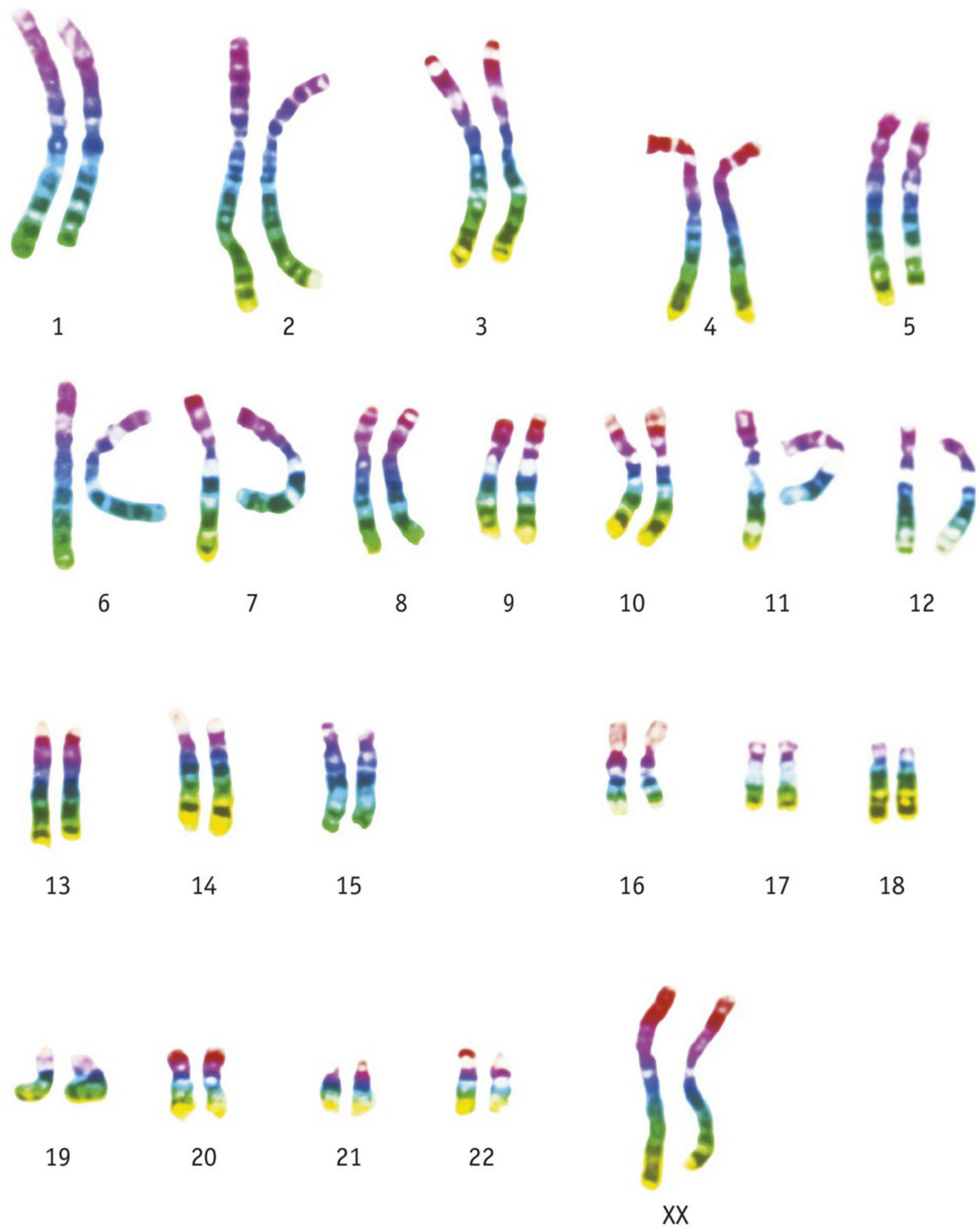
TAXONOMY	LEARNING OBJECTIVES AND EXERCISES		
	5.2.3	5.2.4	5.2.5
Remembering	1a		2
Understanding	3, 4, 6	1bcd, 6	5, 6
Using	7ab, 8, 9, 10	8, 10, 11bcd	7b, 8, 9, 10, 11
Analysing			

Every human has thousands of hereditary characteristics. The information for all of them can be found in just 46 chromosomes. You have two of each chromosome.

PAIRS

Figure 1 shows the chromosomes from a single female body cell, arranged by size and shape. Human cells have 46 chromosomes. Those chromosomes occur in **pairs**, so you have 23 pairs of chromosomes in a cell nucleus. This applies to all body cells.
The two chromosomes of a pair consist of the same genes and thus contain information for the same hereditary characteristics. For example, both chromosomes of pair number 15 have genes with information about eye colour.

fig. 1 A woman's chromosomes, paired.



SEX

The 23rd chromosome pair does not have a number but is designated 'XX' (see figure 1). These are the **sex chromosomes**. In a woman, the sex chromosomes are the same. A woman has two X chromosomes (XX). In a man, the sex chromosomes are different. A man has one X and one Y chromosome (XY, see figure 2).

fig. 2 A man's sex chromosomes.

XY

On rare occasions, girls are also born with XY chromosomes and boys with XX chromosomes. These are intersex forms. Sometimes the intersex status is visible at birth; the baby has both male and female sex characteristics. People can also have the sex characteristics of one sex, with a mixture of male and female chromosomes and/or hormones.

DIFFERENT INFORMATION

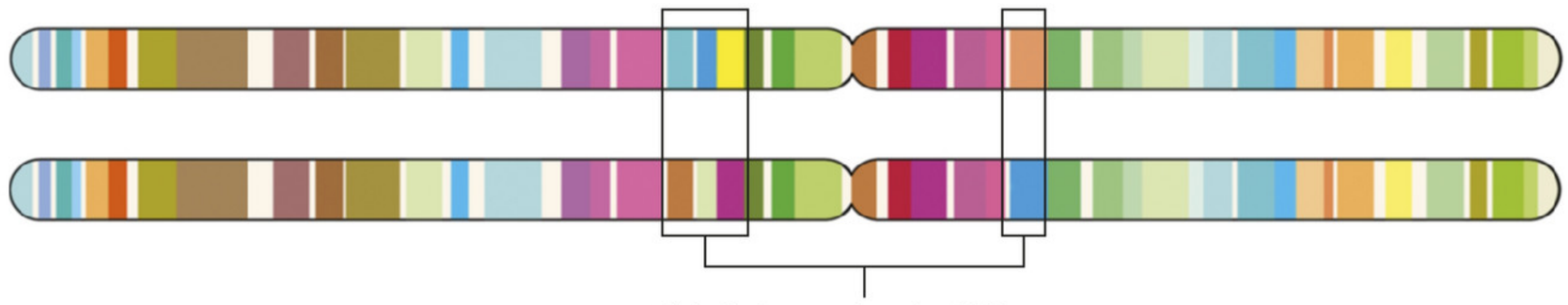
Figure 3 shows a magnified drawing of one chromosome pair. In the drawing, the places where information is stored – the pieces of DNA or parts of genes – have been coloured in (this is not the case in reality, of course). The two chromosomes of a pair contain information for the same hereditary characteristics. The coloured bands are therefore the same width on both chromosomes.

Most of the bands also have the same colour. That means that the information on both chromosomes is the same. For example, both chromosomes may contain the information for blond hair.

Sometimes, the colour of the bands is different. At those points, the information on the chromosomes is not the same. One chromosome may contain information for brown eyes, for example, and the other is for blue eyes. In that case, the chromosomes contain different **variants of a gene**.

One chromosome in each pair comes from the father and one from the mother. The information on the two chromosomes of one pair can therefore be different.

fig. 3 Different information on a chromosome pair.

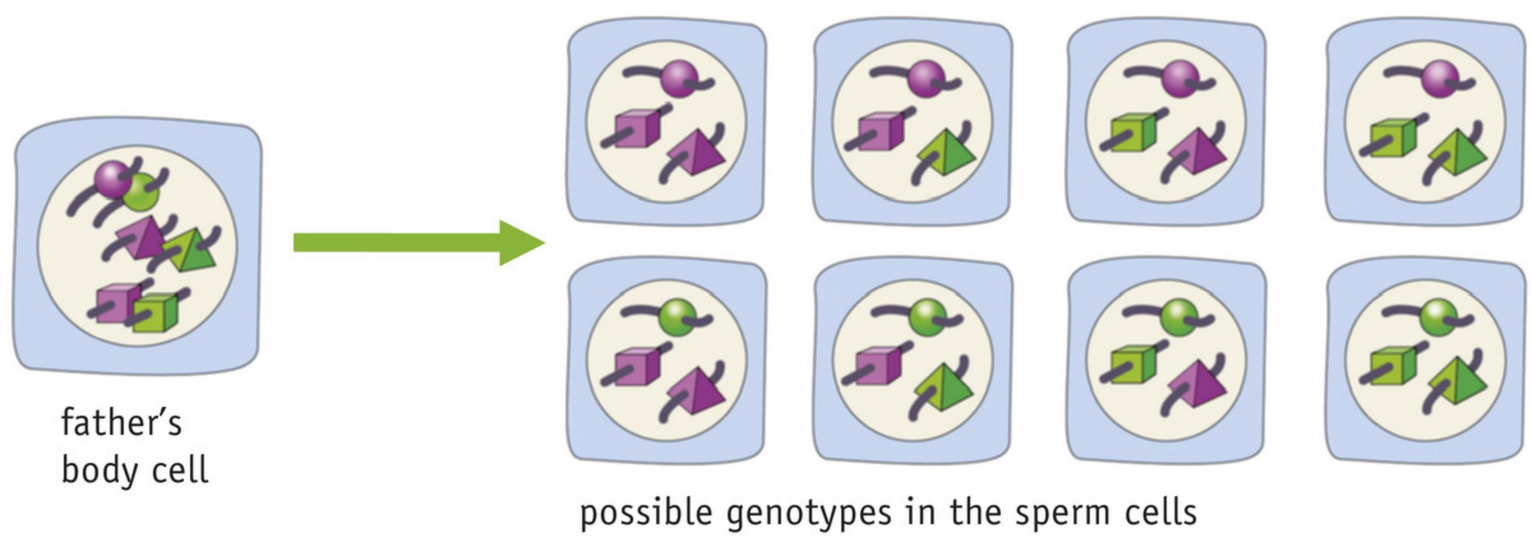


This information is different on the two chromosomes.

SEX CELLS

In sexual reproduction, the nuclei of two sex cells merge (an ovum and a sperm cell). In **sex cells** (gametes), chromosomes do not come in pairs but are just single copies. A human gamete therefore does not contain 46 chromosomes, but instead has only 23. Sex cells are created by a special form of cell division, **meiosis**. In meiosis, the chromosomes are split between the daughter cells (sex cells). Each sex cell only gets a single chromosome from each chromosome pair.
Figure 4 shows schematically how sex cells are created from a body cell. You can see a father's body cell with three chromosome pairs. A coloured block has been drawn on each chromosome. The shapes of the blocks are the same (the genes contain the information for the same genetic characteristic) but the colour is different (the information in the genes is different). From each of these chromosome pairs, one chromosome only goes in a sperm cell. Which of the two chromosomes ends up in a sex cell depends on random chance.
As you can see, there are lots of different possibilities. There is therefore a lot of variation in genotype in sperm cells (just as there is in the ova produced by a woman).

fig. 4 A lot of variation in genotypes is created when sex cells are formed.



VARIATION

The nuclei of a sperm cell and ovum fuse together during fertilisation. The 23 chromosomes of the sperm cell and the 23 chromosomes of the ovum come together in the nucleus of the fertilized ovum. The nucleus of the fertilized ovum contains 46 chromosomes that form 23 pairs. One chromosome in each pair comes from the mother and one from the father (see figure 5).

Which genotype the sex cells have depends on random chance. There are lots of different possibilities. As a result, the offspring has a different combination of chromosomes than the parents. That means the offspring will have a different genotype than either parent. In the case of sexual reproduction, **variation in genotypes** occurs in the offspring (see figure 6).

The sex chromosome in the ovum is always an X. The sex chromosome in a sperm cell can be an X or a Y. During fertilization, an XX pair of chromosomes or an XY pair of chromosomes will be created. The baby becomes a girl or a boy (or on rare occasions, intersex).

fig. 5 Fertilization.

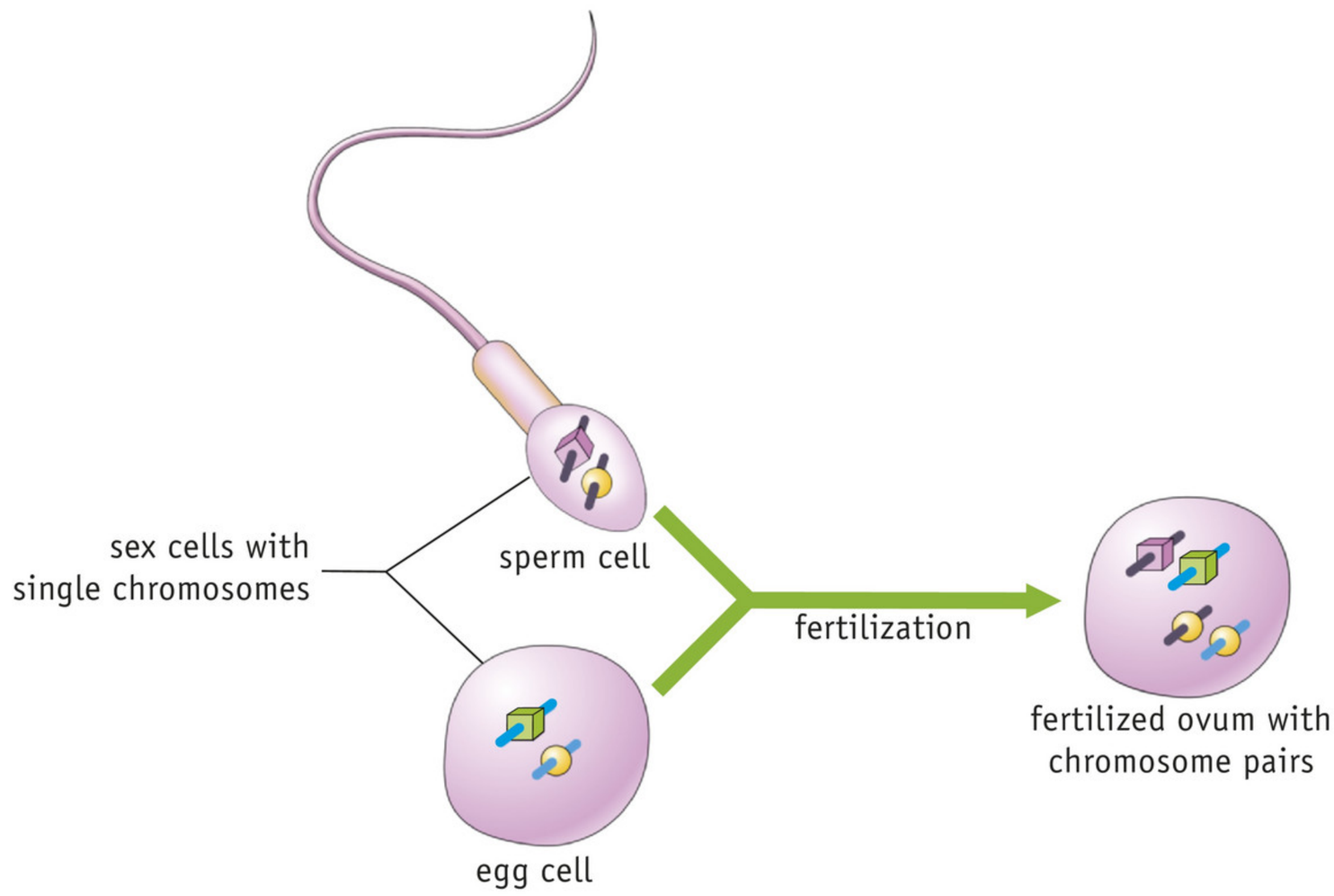


fig. 6 Different phenotypes due to variation in genotype.

KNOWLEDGE

1 Figure 7 shows a researcher looking at all the human cell chromosomes on a screen.

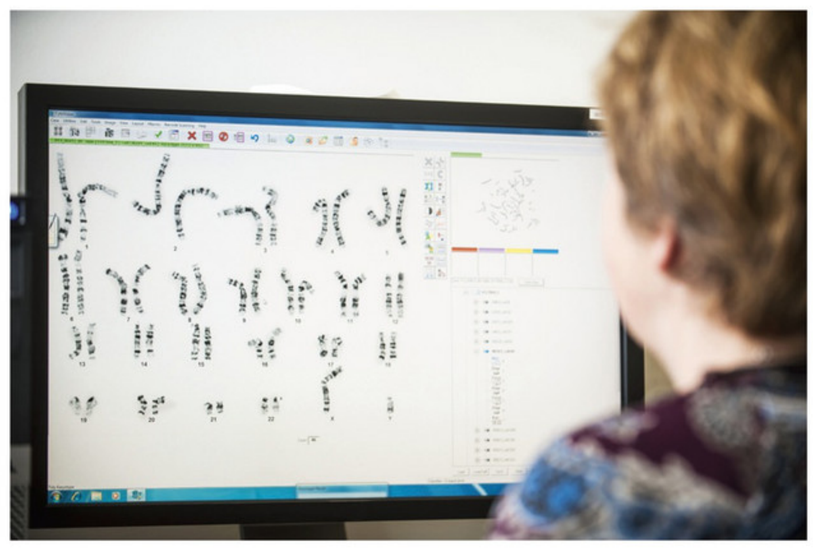
a These must be the chromosomes from a *sex cell* / *body cell* because the chromosomes are *single* / *paired*.

b Is the researcher looking at the chromosomes of a man or woman? Explain your answer.

c The researcher also looks at the chromosomes of a human sex cell. One of the chromosomes is an X chromosome. The researcher concludes from this that the chromosomes originate from an ovum.
Is this conclusion correct? Explain your answer.

d In sexual reproduction, which sex cell determines whether the offspring is a boy or a girl: the sperm cell or the ovum? Explain your answer.

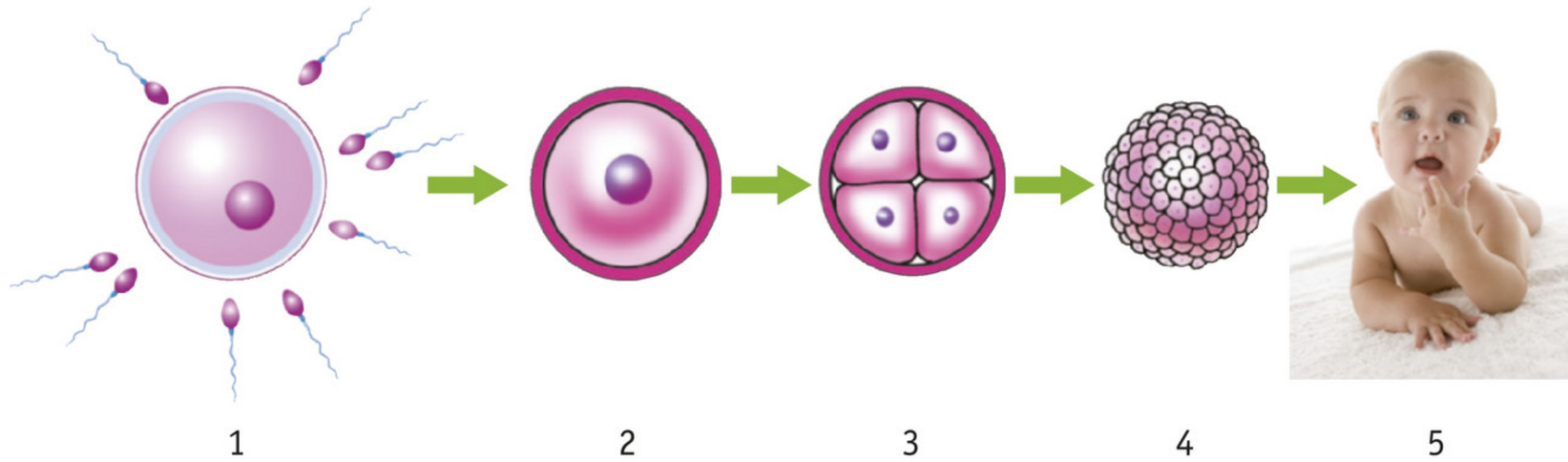
fig. 7 Human chromosomes.



2 Figure 8 shows the development of a human in five steps.
In which step is the genotype defined?

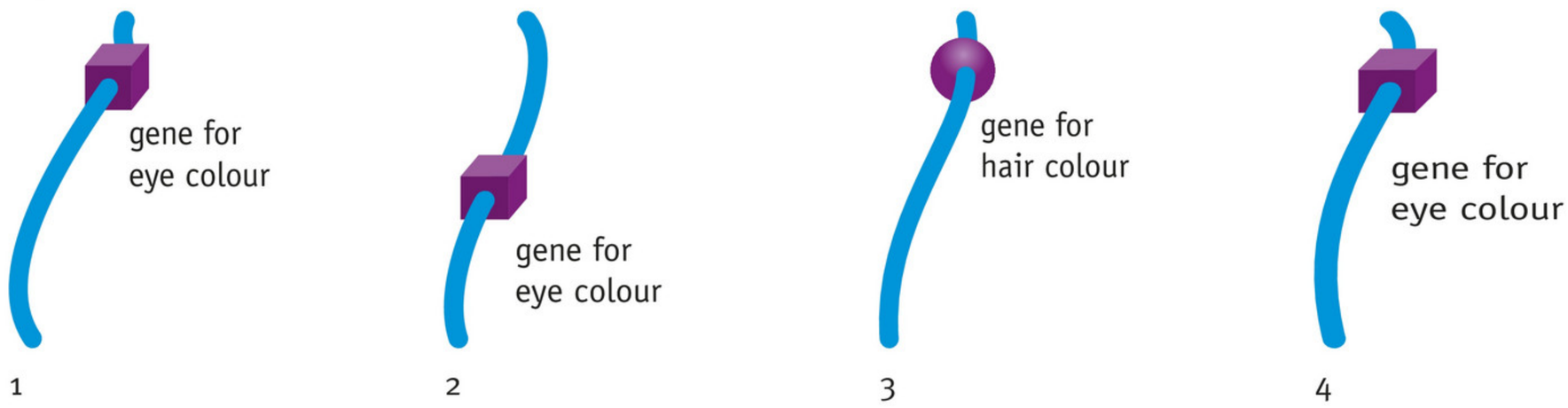
- ○ A in step 1
- ○ B in step 2
- ○ C in step 3
- ○ D in step 4
- ○ E in step 5

fig. 8



3 Figure 9 shows schematic drawings of four chromosomes.
Which chromosome is a pair with chromosome 1? Explain your answer.

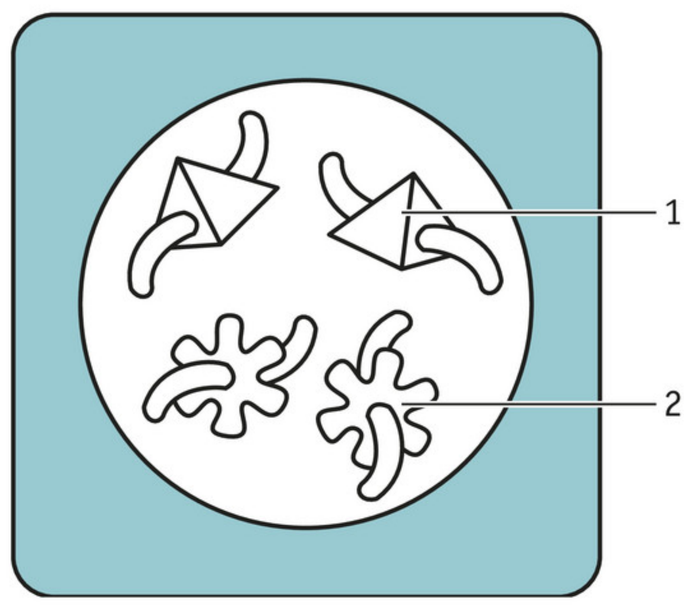
fig. 9



4

Figure 10 shows a schematic drawing of a body cell. Chromosome pair 1 contains genes with information for the hair colour. One chromosome contains information for dark hair and the other for blond hair.
Chromosome pair 2 contains genes with information about eye colour. Both chromosomes contain information for blue eyes.
Colour the chromosomes correctly. You can choose your own colours.

fig. 10



5

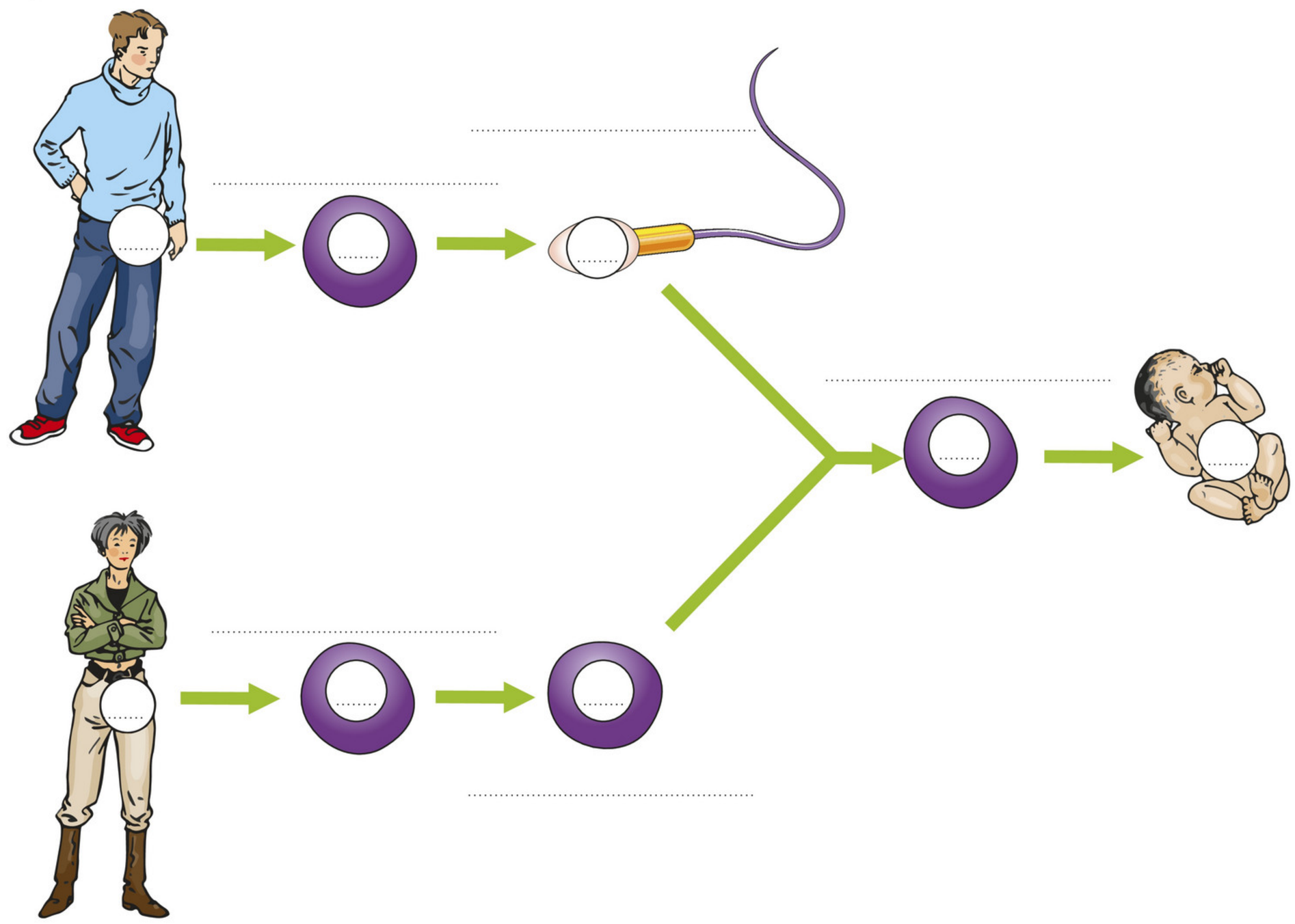
Figure 11 shows a schematic drawing of the formation of sex cells and fertilization in humans.

a Write down what type each cell is. Use the terms *fertilized ovum – ovum – body cell* (2×) – *sperm cell*.

b Fill in the correct number of chromosomes in each cell.

c Does the child have the same genotype as the parents? Explain your answer.

fig. 11



6

Summary

Complete the table and explain how sexual reproduction produces variation in genotypes.

	Male body cell	Female body cell	Male sex cell	Female sex cell
Number of chromosomes				
Single or in pairs				
Maximum number of variants of a gene				
Sex chromosomes				

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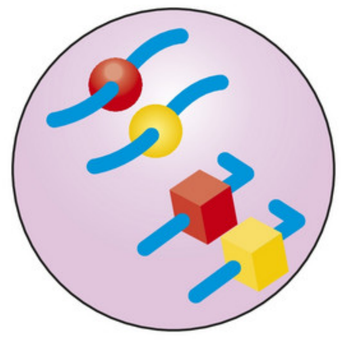
INSIGHT

7

a In dogs, some cells contain 39 chromosomes.
Are these cells sex cells or body cells? Explain your answer.

b Figure 12 is the schematic drawing of a dog's body cell. Four chromosomes have been drawn in the cell. This cell produces sex cells by meiosis.
Draw the various sex cells that meiosis can create.

fig. 12 Body cell of a dog, showing four chromosomes.



8

Tulips are available in all kinds of varieties (see figure 13). The colour of the flowers and the shape of the petals can vary. You can grow new tulips from bulbs or from seeds.
Do growers create new tulip variants using tulip bulbs or seeds? Explain your answer.

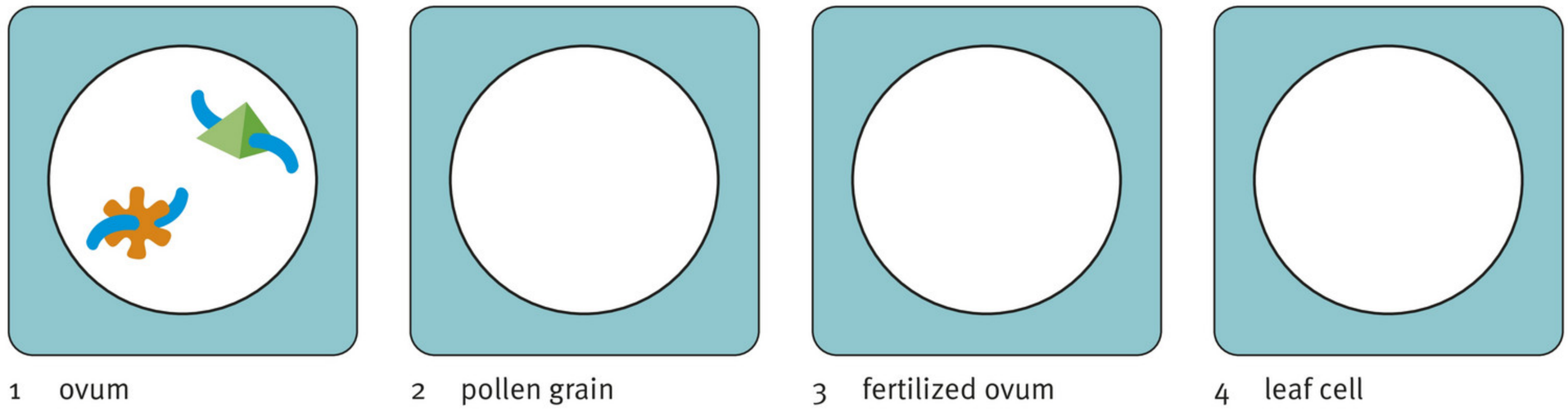
fig. 13 Tulips are available in all kinds of varieties.

9

A grower can grow new plants using sexual reproduction.
Figure 14 shows a schematic drawing of four plant cells. Cell 1 is an ovum with two different chromosomes.

- Draw the chromosomes and genes in the plant's pollen in cell 2.
- Draw the chromosomes and genes in the plant's fertilized ovum in cell 3.
- Draw the chromosomes and genes in the plant's leaf cell in cell 4.

fig. 14



+ 10

In tissue culture, the grower cuts small nodules off a plant. The grower will grow each nodule into a new plant (see figure 15).

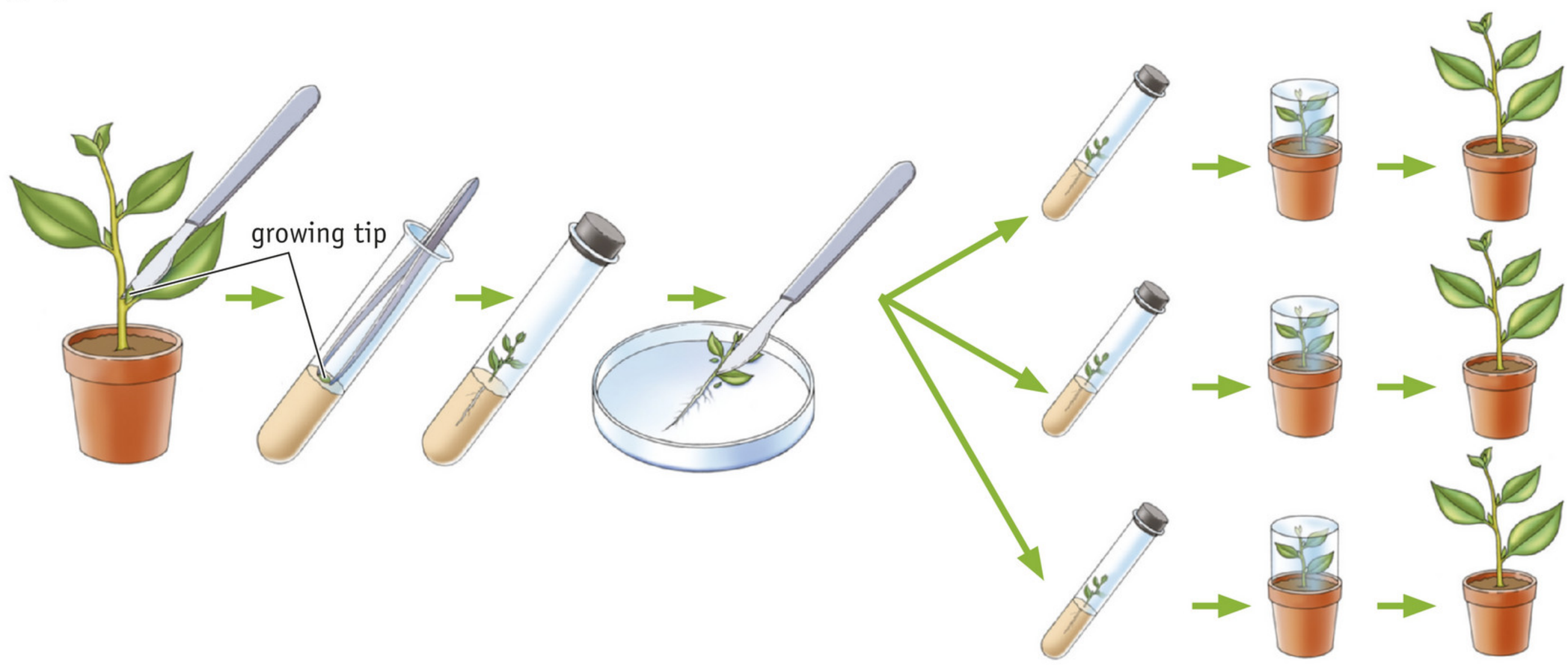
a There is not actually any need to use a whole nodule, as a single cell from a nodule could also grow into a new plant.
Explain how one cell can grow into a complete plant.

b A grower uses a plant for tissue culture. This lets them grow ten new plants. As soon as the plants are large enough, they are put in various places in the garden.
Which statement about the genotype and phenotype of these plants is correct?

- ○ A All the plants have the same genotype and phenotype.
- ○ B The plants only have the same phenotype.
- ○ C The plants only have the same genotype.
- ○ D The plants have different genotypes and phenotypes.

c A grower puts plants that have been grown by tissue culture in various places in a garden. After some time, it is noticeable that the plants do not all look the same.
Explain what causes the differences between the plants.

fig. 15 Tissue culture.



HOW IT FITS TOGETHER the living world

GEMINI

A fertilized ovum develops into a boy or girl. Most children are born as a single child. In about one in eighty pregnancies, twins are born. Two thirds of these are non-identical and one third are identical. Children who are non-identical twins differ just as much as brothers and sisters who were born several years apart. Identical twins are always two boys or two girls who resemble each other very closely. Non-identical twins develop when two ova are fertilized at the same time. Each ovum is then fertilized by a different sperm cell. Identical twins happen when two babies grow from a single fertilized ovum.

fig. 16 Twins.

11 Read the text 'Gemini'.

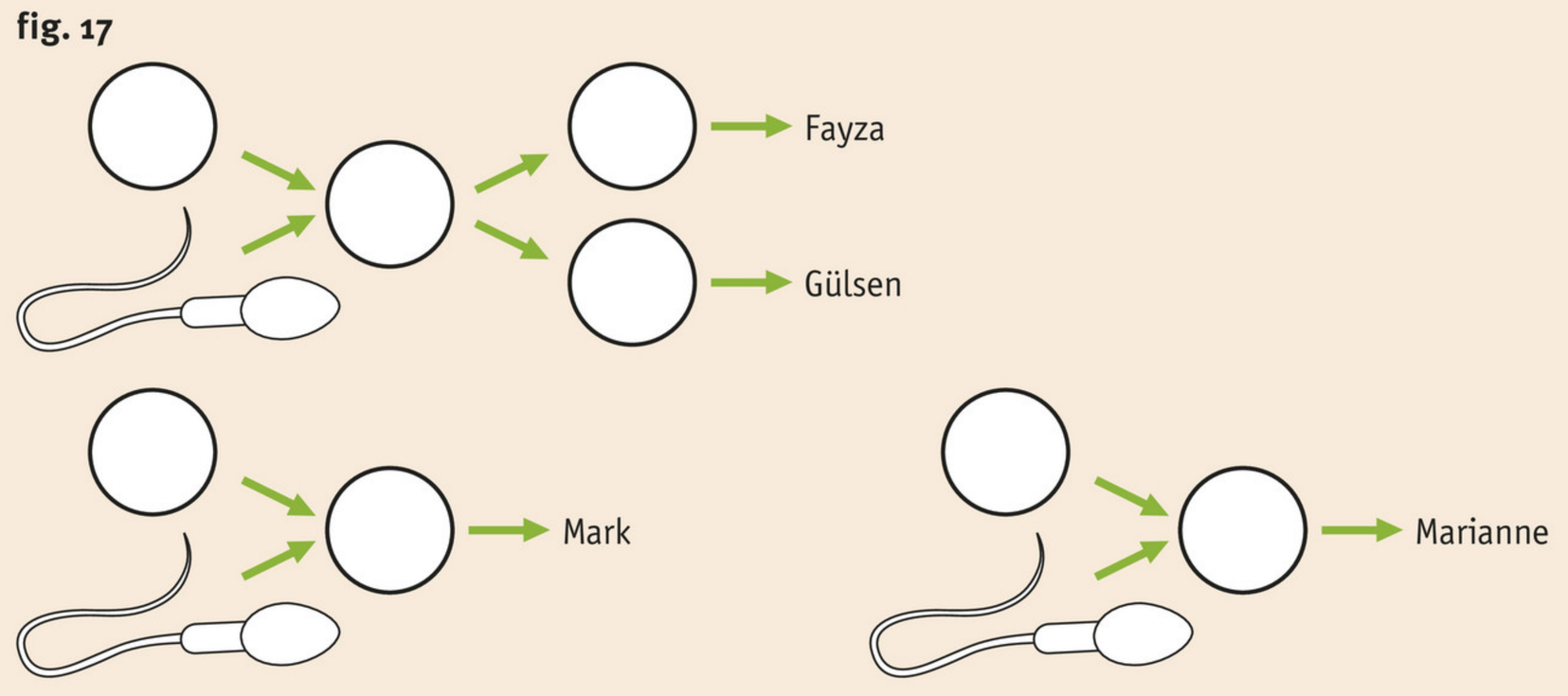
a When do two children with the same parents have the same genotype?

- ○ A When they are identical twins.
- ○ B When they are non-identical twins.
- ○ C When they are born several years apart.

b Jack says that two children who are identical twins are always the same sex. Flora claims that identical twins can be a boy and a girl.
Who is right, Jack or Flora? Explain your answer.

c Figure 17 shows a schematic drawing of how twins happen. The first set of twins are two sisters, Fayza and Gülsen. Mark and Mary are brother and sister.
Write down the sex chromosomes in each cell. by putting an X and/or a Y.

fig. 17



d There are also multiple pregnancies with three or more children. Triplets are usually not all identical but can be a single child and a set of identical twins.
Use a drawing to show how a set of triplets can occur consisting of a single female baby and identical male twins. In all the cells, show the sex chromosomes with an X and/or a Y.

Go to the *Flash cards* and the *Test yourself* section.

3 Genes and alleles

LEARNING OBJECTIVES

5.3.6 You can describe what genes and alleles are.
5.3.7 You can describe what a mutation is.
5.3.8 You can describe what cancer is.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES			
	5.3.6	5.3.7	5.3.8	5.1.1*
Remembering	1a	2bc	2a	
Understanding	1bc, 4	3, 4	4	
Using	10ab	6b, 8abc, 9	7	
Analysing	5, 10cd	6a, 8d		10c

* You can find this learning objective in another Basics section.

Each body cell contains nearly two metres of DNA. The DNA in a single cell consists of about three billion bases (the building blocks of DNA).

DNA

Chromosomes consist largely of DNA. DNA is made up of the **bases** A, T, C and G. A and T always form pairs and so do C and G. One pair (A–T or C–G) is called a **base pair**. Because the base pairs of the DNA are in a specific sequence, a code with information is created. You could compare it to a word that is made up of letters. For example, the four letters could be A, E, T and S. With these letters, you can make various words that have different meanings: east, teas, seat, taste, state, assets, etc. Putting words in a row lets you create sentences that can have many more different meanings.

fig. 1 From organism to base.

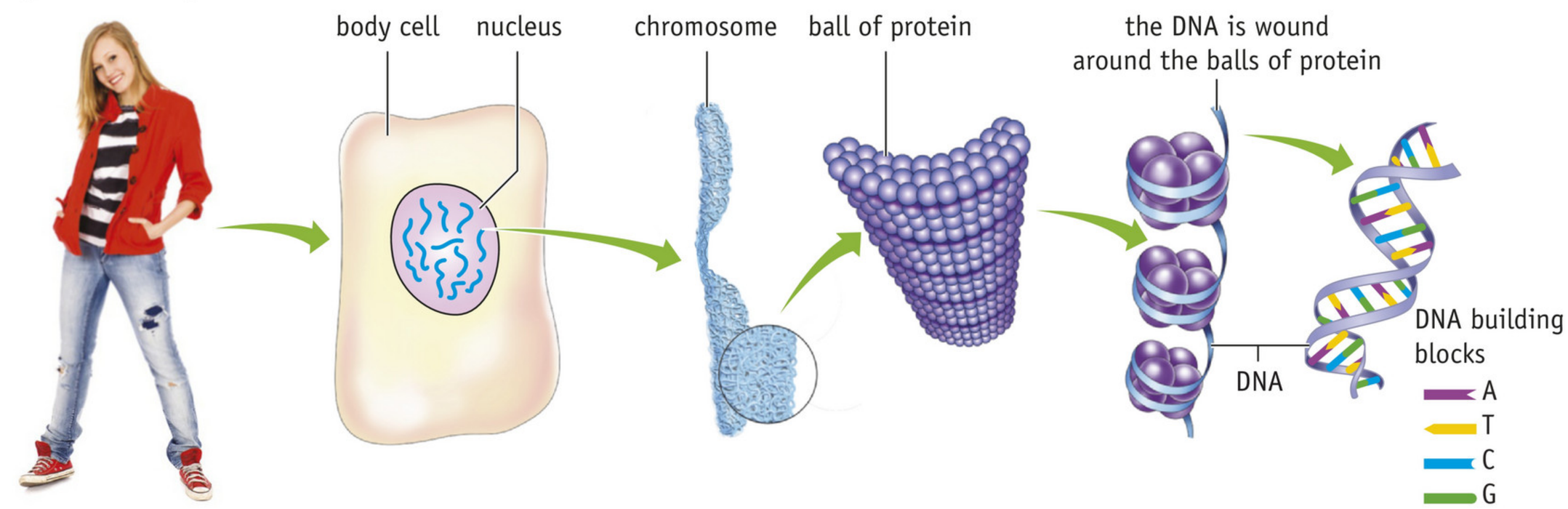
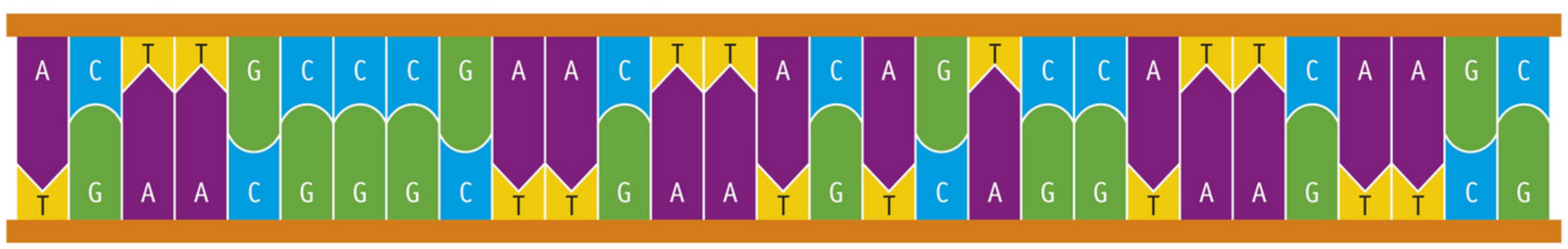


fig. 2 A piece of DNA showing the base pairs.



A C T T G C C C G A A C T T A C A G T C C A T T C A A G C
T G A A C G G G C T T G A A T G T C A G G T A A G T T C G

GENE

Your DNA contains information about what you look like, for example whether you have a cleft in your chin and what shape your big toe is. Your DNA also contains information for making your organs and cells work. For example, your DNA determines whether the sensory cells in your retina can detect the difference between the colours red and green, in other words whether or not you are colourblind.

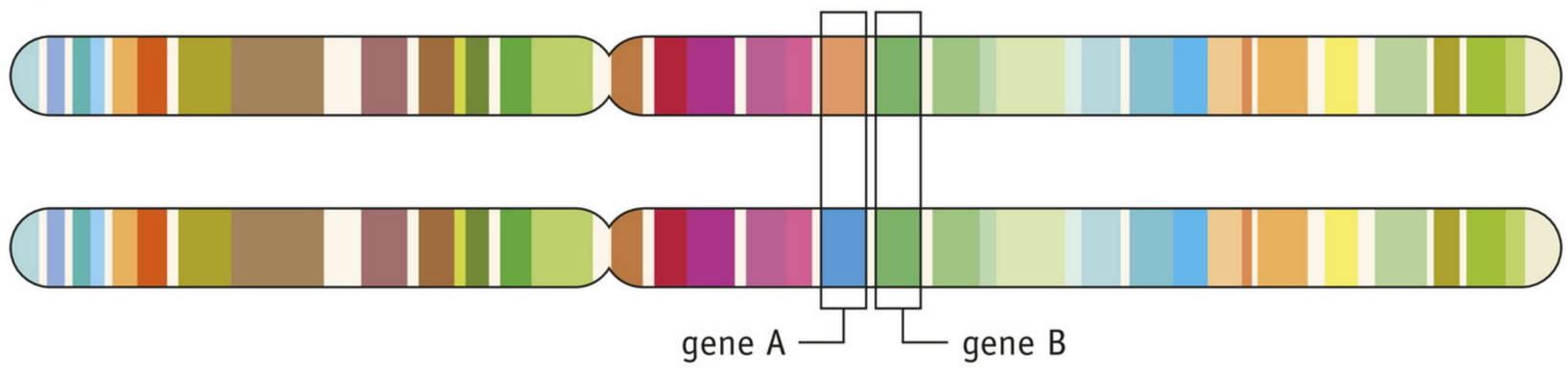
Each characteristic and process can require thousands of base pairs. The set of base pairs that are needed for a characteristic are called a gene. The base pairs of a gene can be next to each other, but they are usually split across one or more chromosomes. All characteristics require multiple genes and the same base pairs can be part of several genes.

The colour, shape and functioning of your body are mostly directly controlled by **proteins**. Genes contain the information for producing these proteins. In a muscle cell, for example, a gene is active that contains the information for producing a muscle protein. In cells of the pancreas, though, a gene is active that contains the information for producing the hormone insulin (which is a protein). The pigment in your eyes (melanin) is also produced by proteins.

GENE VARIANT OR ALLELE

Figure 3 shows a schematic drawing of chromosome pair 15. This chromosome contains two genes that are needed for eye colour: gene A and gene B.

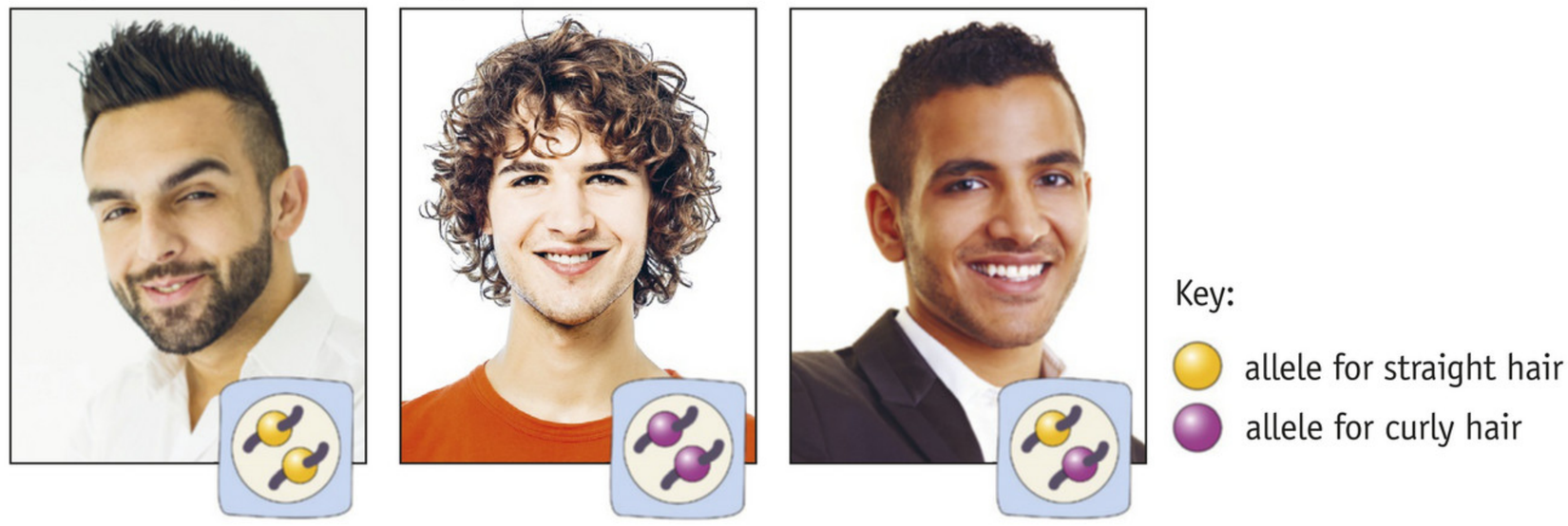
fig. 3 Chromosome pair 15: genes for eye colour.



Gene A and gene B are each made up of thousands of base pairs. In gene B, all these base pairs are exactly the same on both chromosomes. Where there is an A–T base pair on chromosome 1, chromosome 2 will also have an A–T base pair. So gene B has been coloured in green on both chromosomes (to show that the information in the gene is the same on both chromosomes).
In gene A, there are some small differences in the base pairs. On one chromosome, there could be a G–C base pair with information that usually gives blue eyes. In the same place on the other chromosome, there is an A–T base pair with information that usually gives brown eyes. Gene A has therefore been coloured in differently on the two chromosomes.

The information in a gene is called a **gene variant** or **allele**. In figure 3, gene A consists of two different alleles and gene B is made up of two identical alleles. The two alleles of a gene are called an **allele pair**. The exact eye colour of the person in figure 3 depends on which allele is stronger (as it happens, the allele for brown eyes is stronger than the one for blue eyes).
Figure 4 shows allele pairs for hair type.

fig. 4 Allele pair for hair type.



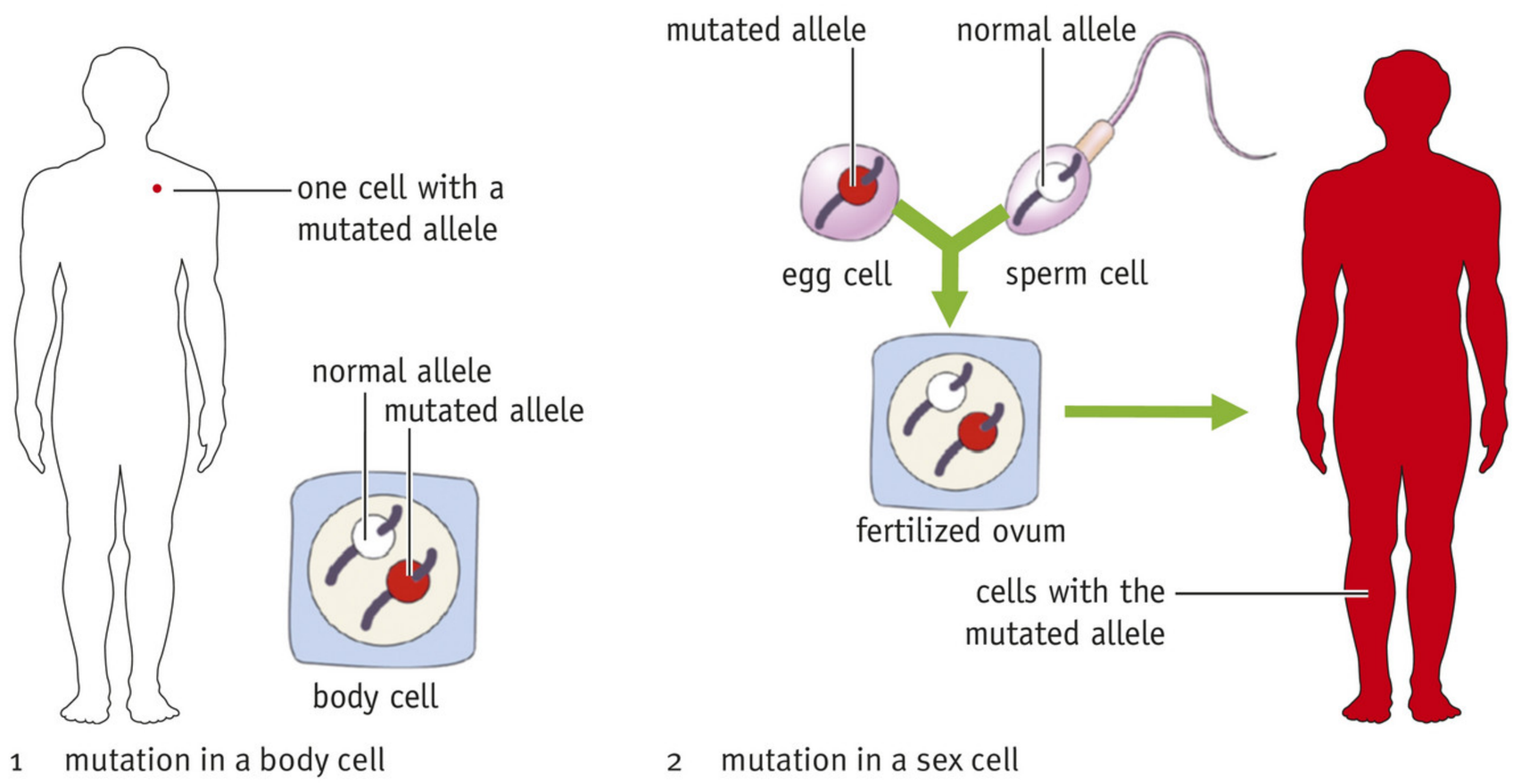
1 two alleles for straight hair
2 two alleles for curly hair
3 one allele for straight hair and one allele for curly hair

MUTATION

A chromosome may get damaged and the information for one or more hereditary characteristics may change as a result. Such a sudden alteration in the genotype is called a **mutation** (meaning a 'change'). In a mutation, one or more alleles have **mutated** (changed).

Mutations can take place in any cell. A mutation mostly has no consequences. If one cell in your body develops a mutation, the other body cells remain unaffected. You will not even notice that you have a cell with a mutated allele (see figure 5.1). However, if a mutated allele happens in a sex cell, the mutation may have a major effect. When this sex cell fuses with another sex cell, the mutant allele ends up in the fertilized ovum. Every body cell of the offspring that develops from it will have the mutated allele (see figure 5.2). Whether or not this affects the phenotype depends on how strong the allele is.

fig. 5 The influence of a mutation.

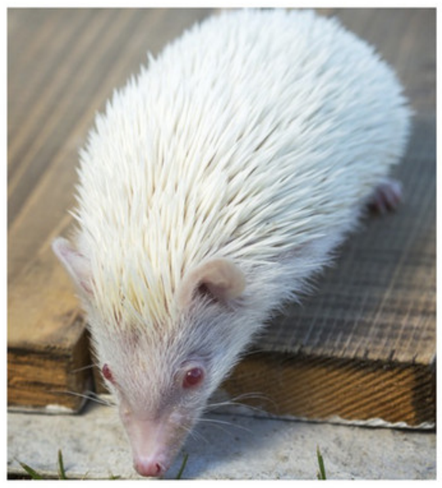


1 mutation in a body cell
2 mutation in a sex cell

ALBINISM

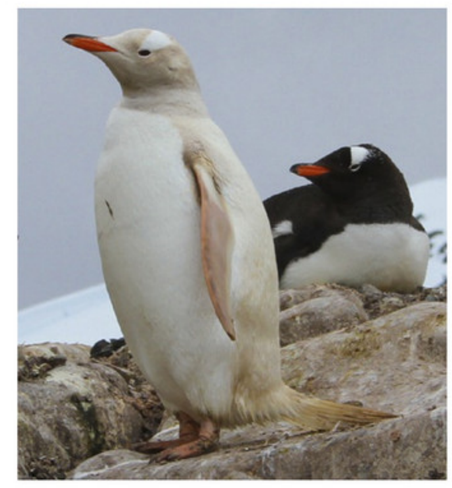
An organism in which a mutation is visible in the phenotype is called a **mutant**. One example of a mutant is an **albino**. In an albino, the body is unable to form melanin: a pigment, the substance that colours hair, eyes and skin. As a result, the eyes look red and the organism is very pale (see figure 6.1). Mutations in genes for producing melanin are clearly visible in the phenotype (see figures 6.2 and 6.3). Most mutations are not.

fig. 6 Albinism and pigment mutation.



1 albino hedgehog

2 pigment mutation in a human



3 albino penguin

MUTAGENIC INFLUENCES

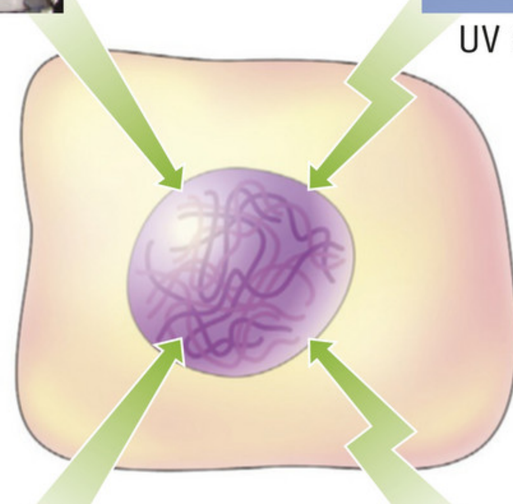
The DNA can get damaged (mutate) as a result of radiation (for instance radioactivity, UV radiation or X-rays) and chemical substances (for example asbestos or substances in cigarette smoke). These are called **mutagenic influences** (see figure 7).

In 1945, two atomic bombs were dropped on Japan. As a result, a huge amount of radioactive radiation was released. Even now, Japan has a much higher number of children born with physical and mental abnormalities than other countries. Japanese people who were exposed to radioactivity and their offspring have more mutated alleles than average in their sex cells.

fig. 7 Mutagenic influences.

asbestos dust

UV radiation



cigarette smoke

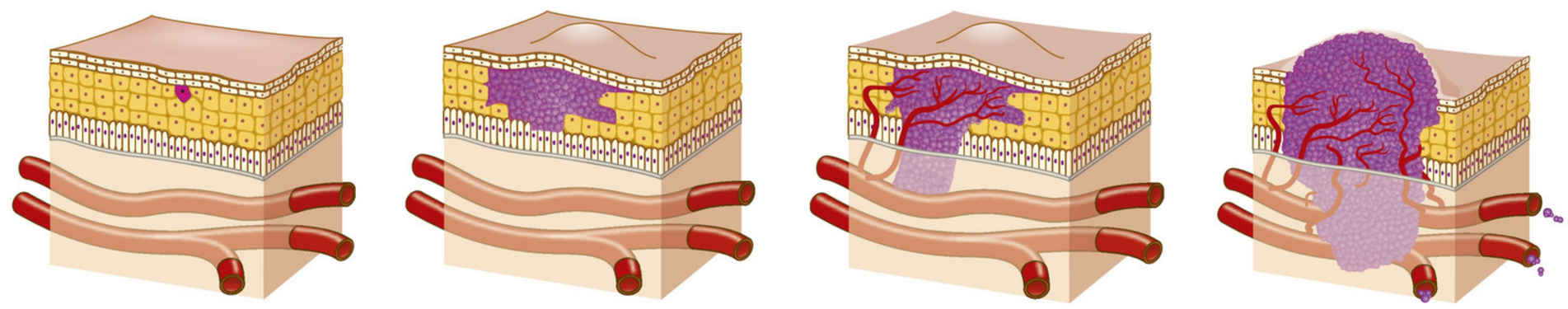
X-rays and radioactivity

CANCER

The rate at which cell divisions occur in the body is controlled by the DNA. But sometimes a cell can start dividing out of control. This is caused by mutations in the genes that regulate cell division. This then creates a swelling or **tumour**. Some tumours grow slowly and do not disrupt the structure of the tissues. These tumours are benign. If they get too large, they can be surgically removed. Other tumours are **malignant**. A malignant tumour grows rapidly and disrupts the structure of the tissues around it (see figure 8). A malignant tumour is called a **cancer**.

Cells from the cancerous tumour can enter the blood or lymph (see figure 8.4). The cells are then carried along and reach other parts of the body, There they can once again start dividing out of control, producing tumours everywhere in the body. This is called **metastasis**.

fig. 8 How cancer arises (schematic).



1 Mutations have occurred in a single cell, making the cell a cancer cell.

2 The cancer cell's division is uncontrolled.

3 The tumour disrupts the structure of the tissues.

4 Metastasis: tumour cells get into the blood or the lymph.

KNOWLEDGE

1 Here is a piece of DNA. One base has been filled in for each base pair.

a Fill in the missing bases.

T	A	C	A	C	C	G	G	G	T	T	A	T	A	T	C	G	G	G	A	A	C	A	T	T

b Could this piece of DNA hold all the information for one characteristic? Explain your answer.

c The exact base sequence of this piece of DNA occurs once on the chromosomes in a woman's ovum.

- Can this sequence occur twice in a fertilized ovum? *yes / no*
- Can this sequence occur twice in a white blood cell? *yes / no*
- Can this sequence occur twice in a sperm cell? *yes / no*

2 **a**
- A *benign / malignant* tumour is one that interferes with the structure of the tissues.
- A *benign / malignant* tumour grows slowly.
- A tumour that spreads by metastasis is *benign / malignant*.

b A tumour can be caused by a sudden change in the genotype.

What is a sudden change in genotype called? .....

c Write down four environmental influences that can cause a sudden change in the genotype.

3 Figure 9 shows a white tiger. The animal has a white coat with black stripes and blue eyes (although you can't see that clearly in the picture).
Is the white tiger an albino? Explain your answer.

fig. 9 A white tiger.

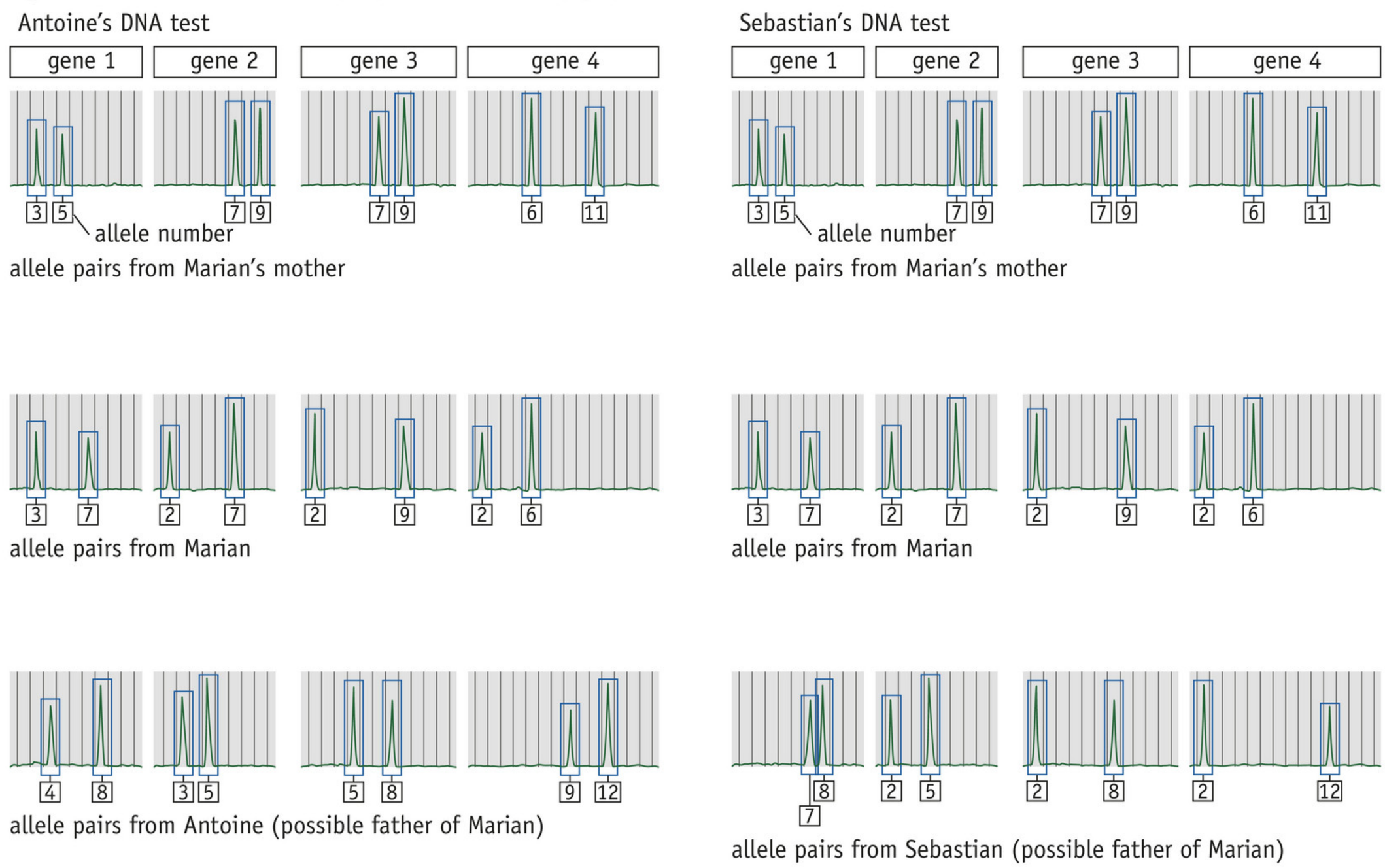
4 **Summary**

Explain the following terms in your own words: allele, gene, cancer, mutagenic influence and mutation.

INSIGHT

5 In all humans, half the alleles come from the father and half from the mother. A DNA kinship test can determine whether a man is a child's father.
Marian wants to find out who her biological father is, Antoine or Sebastian. Figure 10 shows the result of the test on four genes.
Explain who Marian's biological father is.

fig. 10 DNA tests of Antoine (left) and Sebastian (right).



6 Figure 11 shows two pieces of DNA: the sequence from an allele of the parent cell on the left and the same piece of DNA from the daughter cell on the right.

a Did a mutation occur during cell division? Explain your answer.

b Can a mutation cause a hereditary disorder? Explain your answer.

fig. 11

Cell 1: parent cell

C	**C**	**A**	**G**	**T**	**G**
G	G	T	C	A	C

Cell 2: daughter cell

C	**C**	**A**	**C**	**T**	**G**
G	G	T	G	A	C

7 A cancerous tumour can be removed by surgery. In cases of metastatic cancer, surgery is not enough.
Explain why surgery is then not enough.

8

a What mutagenic influence is the main cause of skin cancer?

- ○ A asbestos dust
- ○ B X-rays and radioactive radiation
- ○ C cigarette smoke
- ○ D UV radiation

b Melanin is the pigment for skin, hair and eyes. The more melanin, the darker the skin. Who is more likely to get skin cancer: someone with pale skin or someone with dark skin? Explain your answer.

c Like the sun, the lamps in a sunbed give off UV radiation. Some people want to make sure their skin won't burn during their holiday, so they go to a tanning salon before going on holiday.
Is it smart to go to the tanning salon to get a tan? Explain your answer.

d Young people under 18 are not allows to use sunbeds. Explain why not.

+ 9

A vet regularly takes X-rays. He wears a lead apron when he takes them (see figure 12). Lead stops X-rays. A lead collar fits around the neck. This protects the thyroid gland from radiation. That particular organ is very susceptible to radiation, especially in people under 30.
Which other part of the body is it very important to protect against X-rays? Explain your answer.

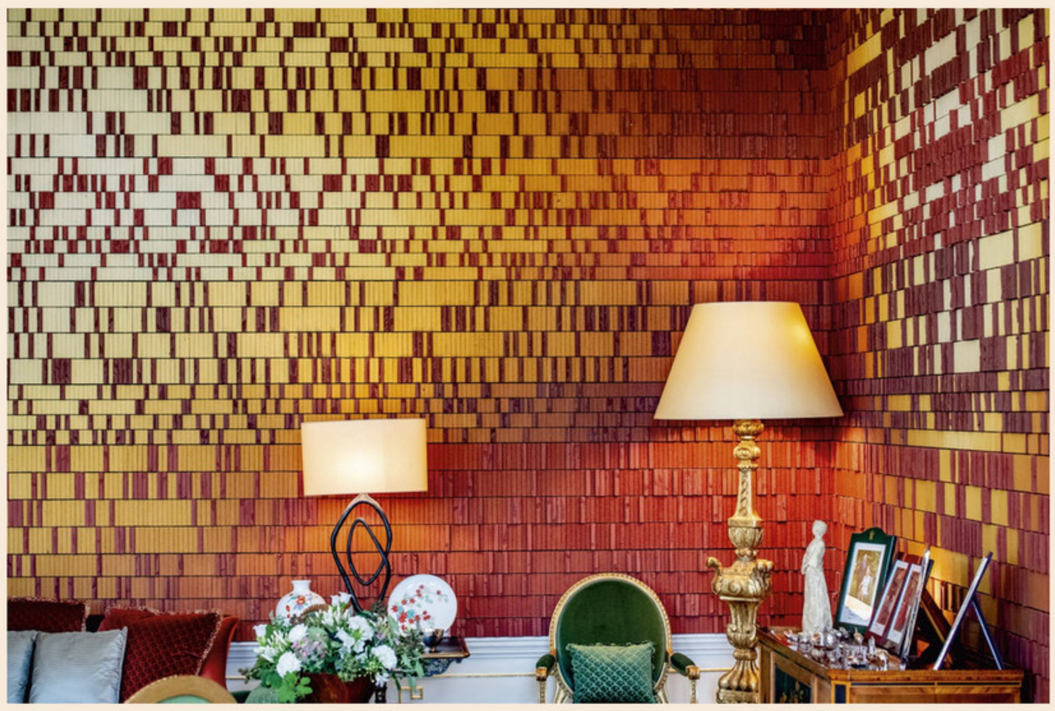
fig. 12 A lead apron protects against X-rays.

HOW IT FITS TOGETHER the living world

HUIS TEN BOSCH PALACE

In 2019, King Willem-Alexander and his family moved to the palace called Huis ten Bosch. To make the palace suitable for living in again, it was completely redecorated. The renovation took three years. One of the most striking rooms in the palace is the DNA Drawing Room. The walls of this room are covered with sixty thousand tiles that represent part of the king's hereditary information. For privacy reasons, only certain parts of the hereditary information were used. This prevents an expert from getting information from the tiles that should not be made public, such as information about whether the king might have certain hereditary disorders. The room also uses pieces of DNA from the queen and the princesses. In a way, the walls are a 'portrait' of the royal family.
Would you like to have your DNA on your walls at home? If so, you'd better get started right away: it would take three billion (3,000,000,000) tiles stuck on the wall to display all your genetic information. Quite a job!

fig. 13 The DNA Drawing Room in Huis ten Bosch.



10 Read the text 'Huis ten Bosch Palace'.

a The wall consists of horizontal strips four tiles high.
What does each brown tile in the DNA Drawing Room represent?
- ○ A an allele
- ○ B a base
- ○ C a DNA strand
- ○ D a gene

b In each strip, each column has just one brown tile.
Explain how the base pairs are displayed in the correct order in the DNA Drawing Room.

c A portrait is a representation of a person. In most cases, it is a picture or a painting. The designer of the wall also calls the DNA design a portrait. Explain why.

d Imagine that all the king's hereditary information was known.
Is it possible for an artist to use that information to paint a portrait that looks just like him? Explain your answer.

Go to the *Flash cards* and the *Test yourself* section.

4 The theory of evolution

LEARNING OBJECTIVE

5.4.9 You can describe the theory of evolution.

► Practical activity 1

TAXONOMY	LEARNING OBJECTIVE AND EXERCISES
	5.4.9
Remembering	1ab, 2b
Understanding	1c, 2a, 3, 4
Using	5, 6ab, 7bc, 9b
Analysing	6c, 7a, 8, 9acd

There are millions of different species of organisms on Earth. These forms of life can look very different (see figure 1). Species can appear, change and disappear.

EVOLUTION

Life forms on the Earth have evolved and changed over time. The development of life on Earth, with species appearing and changing and/or disappearing, is called **evolution**. The **theory of evolution** was developed by Charles Darwin, a nineteenth-century English scientist. He based it on a timescale of millions of years, variation in genotypes, natural selection and the creation of new species.

fig. 1 Life forms.

VARIATION IN GENOTYPES

Most plants and animals reproduce sexually. Sexual reproduction produces variation in genotypes. Mutations can also cause variation in genotypes. New genotypes can result in new phenotypes (see figure 2).

fig. 2 Variation in phenotypes.

1 in tomatoes

2 in ladybirds

3 in snails

NATURAL SELECTION

Some organisms have a lot of offspring. In a single spring, a female frog can lay three thousand eggs in a pond. But the pond does not contain enough food for that many frogs.
Not all frogs have an equal **chance of survival**. Frogs in poor health or with a different colour are more likely to be caught by predators. These frogs only live a short time and do not have much chance to have offspring. Frogs that are healthy and strong and well camouflaged have the greatest chance of staying alive and having offspring. Darwin called this phenomenon **natural selection** (see figure 3).

fig. 3 Natural selection in tadpoles.

How well adapted an animal is to the environment can vary. This is mainly determined by the genotype. An animal that is well adapted to its environment has a greater chance of survival. Many of this animal's offspring will probably remain alive and reproduce. The characteristics that are favourable to survival are passed on to the offspring.
An animal that is poorly adapted to its environment is likely to have fewer offspring, if any. The unfavourable genotype is therefore much less likely to be passed on to descendants. This applies to all organisms, not just animals.

Sexual reproduction continuously creates new genotypes (variation), and the conditions for a species can change over and over again. Natural selection therefore allows species to change constantly.
One example is the giraffe, with its long neck (see figure 4). A giraffe with a slightly longer neck than other giraffes can eat more tree leaves. It has more chance of surviving and having offspring, who will also have longer necks. This leads to more and more giraffes with longer necks, who can eat leaves that other species cannot reach. The species changes and is better adapted to the conditions.

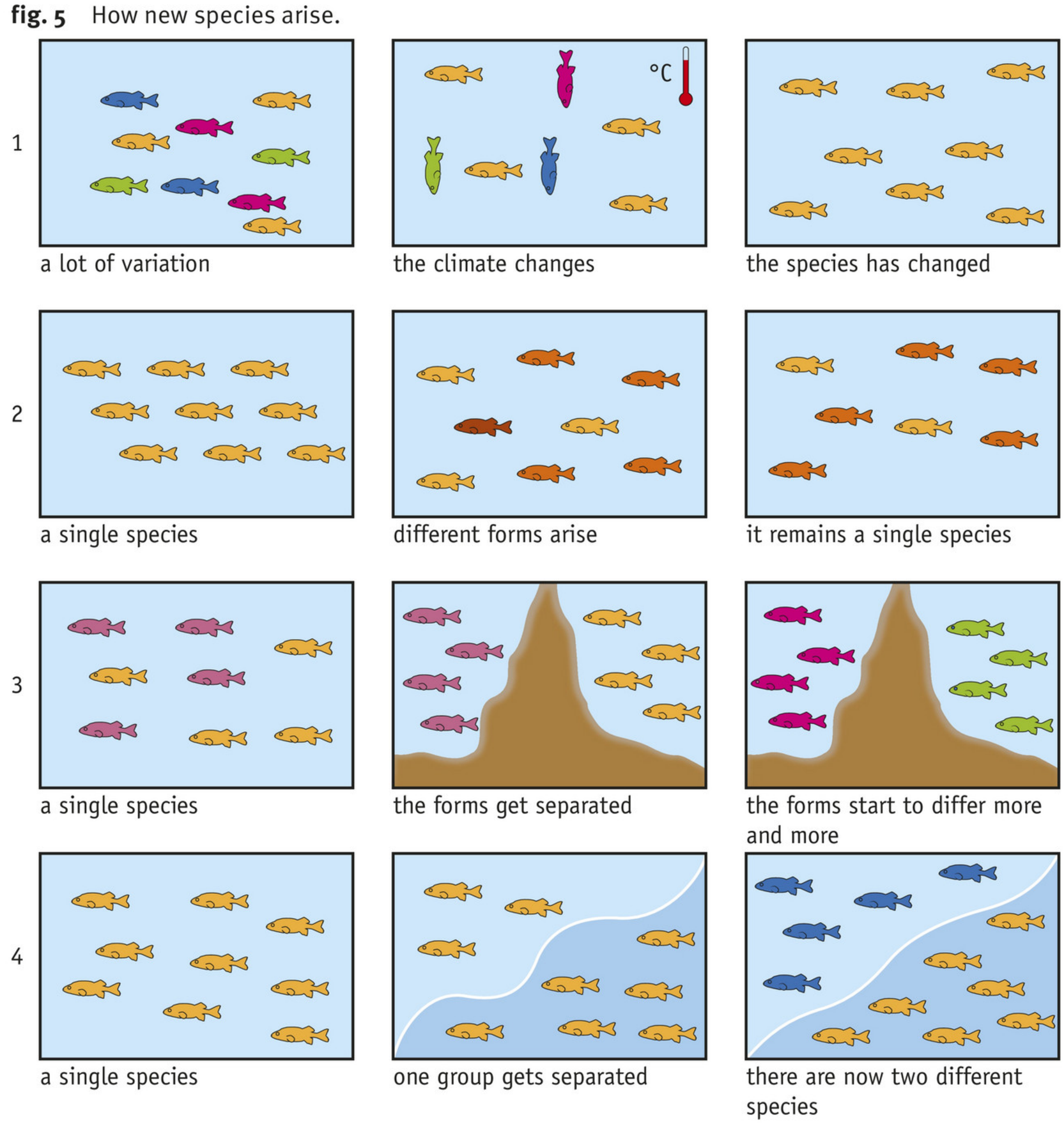
fig. 4 A long neck is a useful adaptation for a giraffe.

HOW NEW SPECIES ARISE

A species as a whole has a greater chance of survival if it has many different genotypes and phenotypes, creating a lot of variation. When the conditions change, there is a greater chance that there will be some organisms with the right characteristics for those new conditions.

The climate can change, for example. If there is a lot of variation in genotypes and phenotypes within a species, there are probably also organisms with characteristics that are favourable in the new climate. If these organisms reproduce, they pass their genes on to their offspring (see figure 5.1). The offspring then inherit the favourable characteristic, while the variation in genotypes for other characteristics continues within the species. Other members of the same species who do not have the genes for the favourable characteristic are less well adapted to the new climate. The likelihood of them reproducing is smaller. If only the organisms with the new, different form continue to live, the species has changed.

fig. 5 How new species arise.



It is also possible that both forms continue to exist alongside each other. Organisms with the original form and organisms with the new, different form reproduce amongst themselves then. Many kinds of mixed forms are therefore created. If the organisms of different forms continue to reproduce together, they remain members of the same species (see figure 5.2). A new species will then not arise. However, different forms of the species are created such as different dog breeds, for example. They all belong to a single species because they can reproduce among themselves.

The different forms of a species can become isolated from each other, separated for example by a river, mountains, ice, the desert or sea. The two forms may become more and more different (see figure 5.3). After a long time, organisms of the two types are no longer able to reproduce and have fertile offspring together. The two forms have then become two species. So different species can be created by **isolation**.

The same can happen when one group of organisms of a species becomes isolated from the rest of the species. Over time, the environments in the two habitats can diverge. Each group of organisms develops its own adaptations to their environment (see figure 5.4). As a result, two different species can develop.

KNOWLEDGE

1

a What is evolution?

b Who came up with the theory of evolution?

c This is a summary of the essence of the theory of evolution. Complete the following text correctly.
Variation in genotypes occurs as a result of *sexual* / *unsexual* reproduction. The genotypes of individuals of the same species is therefore *always* / *never* exactly the same. The characteristics of individuals of the same species are therefore *always* / *never* exactly the same. Characteristics that allow an individual to survive better are passed on to the next generation *less* / *more* often. As a result, a species can adapt or change.

2

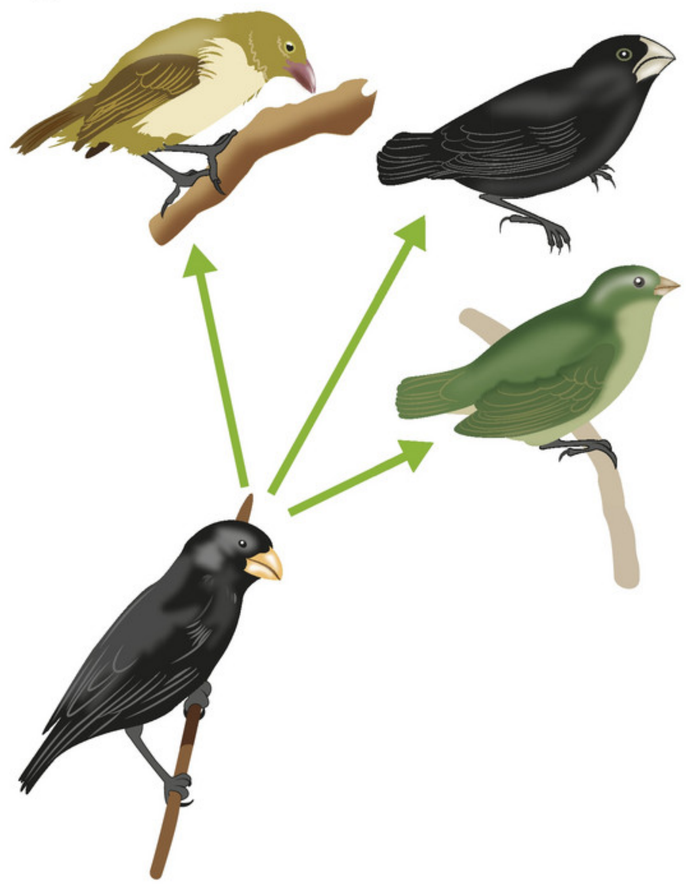
Figure 6 shows how evolution created three species of finches from a common ancestor.

a From what moment is something said to be a new species?

- ○ A From the moment that the different forms are isolated from each other.
- ○ B from the moment the different forms cannot reproduce together.
- ○ C From the moment that each type specializes in a different type of food.
- ○ D From the moment that different phenotypes have arisen.

b There are many different genotypes for a particular species of finch.
Does this finch species have a better or poorer chance of survival if the environment changes? Explain your answer.

fig. 6 Diversification in finches.



3 Foxes live in temperate climates and also in the Arctic and the Sahara. Arctic foxes and desert foxes have adaptations to keep their body temperature constant (see figure 7). The Arctic fox has a thick layer of fat, a white coat and small ears. The desert fox has a thin coat and large ears.

a Explain how each characteristic helps the fox adapt to its environment.

b The desert fox is descended from the common foxes that live in temperate climates. Long ago, a group of foxes went into the Sahara and evolved into the desert fox. Explain how the evolution into a desert fox progressed. Use the following terms in your explanation: *genotype – mutation – natural selection – variation*.

fig. 7

1 Arctic fox

2 desert fox

4 **Summary**

Describe how the theory of evolution says that species can arise, change and disappear.

INSIGHT

5 Figure 8 shows a mountain pansy. This plant only occurs in places where there is a lot of zinc in the soil, such as the Geuldal in South Limburg. This species has adapted to life in places with a lot of zinc contamination.
Because of cross-pollination with pollen from garden pansies, the number of zinc pansies has decreased.
Explain why cross-pollination with garden pansies is a threat to the mountain pansies.

fig. 8 A mountain pansy.

6 Figure 9 shows that dogs with all kinds of phenotypes occur. Although dogs can be very different, all dogs belong to the same species.

a What tells you that all dogs belong to the same species?

b When breeding dogs, breeders apply 'artificial selection'.
Explain how breeding dogs created so many different breeds.

c You could say that breeding dog breeds is the opposite of evolution. Explain how.

fig. 9 Dog breeds.

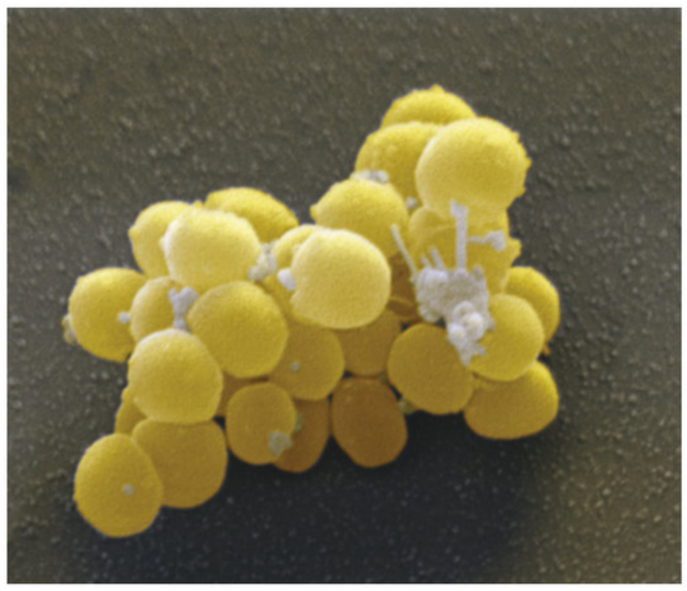
7 The bacterium *Staphylococcus aureus* is found in many hospitals. Some of the bacteria have become insensitive (resistant) to antibiotics. These bacteria are called MRSA bacteria or hospital bacteria (see figure 10).

a Explain how variation in genotypes can occur in bacteria.

b Explain why bacteria evolve much faster than humans.

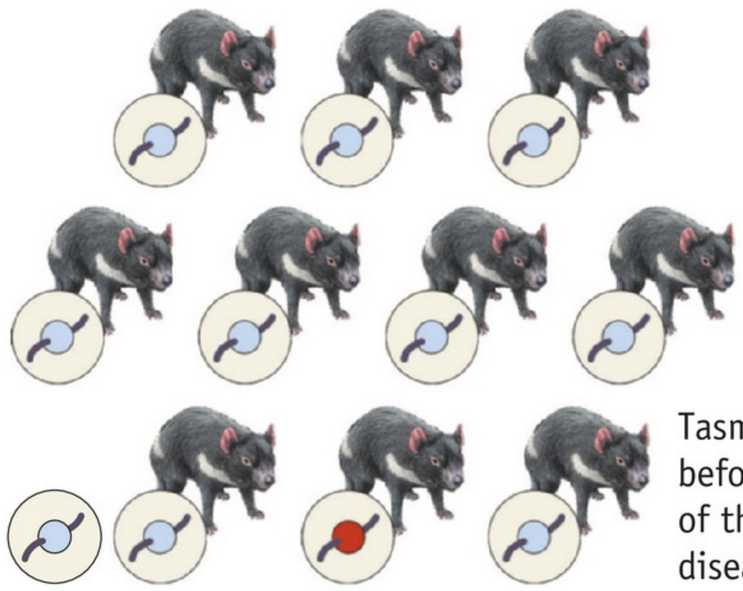
c Doctors have warned about overuse of antibiotics. They are afraid that antibiotics will no longer work in the future.
Explain why the efficacy of antibiotics might be reduced.

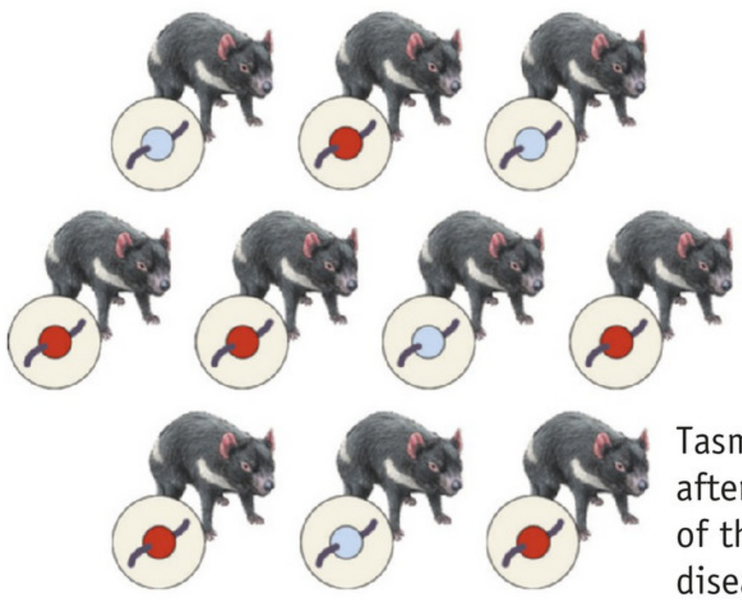
fig. 10 MRSA bacteria.



+ 8 The Tasmanian devil is a marsupial that lives on the Australian island of Tasmania (see figure 11). A deadly infectious disease threatened the animal with extinction. However, it now looks as if the animal will survive after all. Some of the animals have an allele that makes them sexually mature earlier.
Explain how this allele can save the Tasmanian devil from extinction.

fig. 11 A Tasmanian devil.





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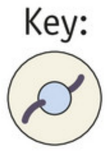

allele for slow reproduction

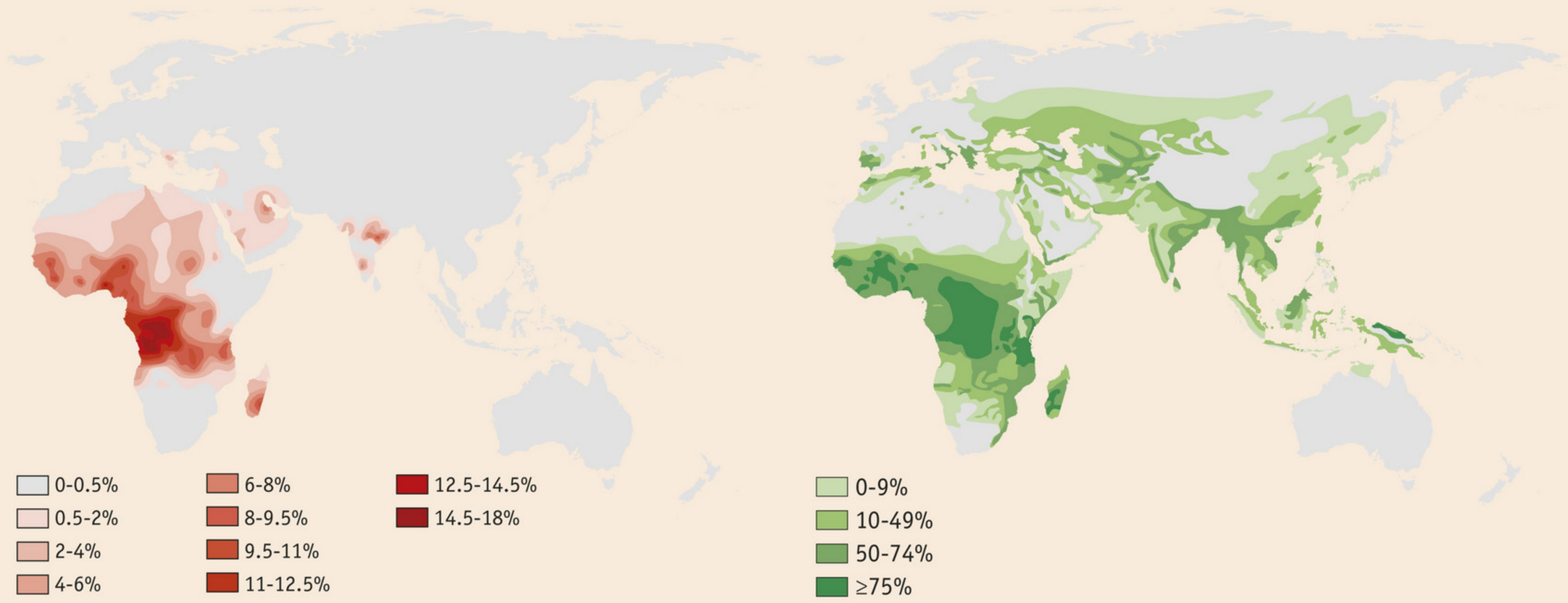
allele for rapid reproduction

HOW IT FITS TOGETHER the living world

MALARIA AND SICKLE CELL ANAEMIA

Malaria is an infectious tropical disease. The pathogen is transmitted by mosquitoes. Malaria is a serious disease. You get a high fever and red blood cells are destroyed. This leads to blockages in the blood vessels. Without treatment, the chance of dying is 95%.
Another disease that occurs mainly in tropical regions is sickle cell anaemia. In this disease, the red blood cells contain an abnormal type of haemoglobin. As a result, the red blood cells are deformed. As a result, they cannot flow well through the capillaries, meaning that too little blood gets to the tissues.
Sickle cell anaemia is a hereditary disease. The disease is caused by a mutation in the gene for producing haemoglobin. Someone who has the mutation in both alleles has a severe form of sickle cell anaemia, with pain attacks, fever and tissue damage. These people often die before reaching age 50. If only one allele is mutated, the disease is less serious and people with one allele for sickle cell anaemia seem to be more resistant to malaria.

fig. 12 Regions with sickle cell anaemia and malaria.



1 percentage of people with the allele for sickle cell anaemia 2 percentage of children with malaria

9 Read the text 'Malaria and sickle cell anaemia'.

a Compare the distribution ranges of sickle cell anaemia and malaria. What do you notice?

b Who has the greatest chance of surviving in an area without malaria?
- ○ A Someone with one mutated allele for the production of haemoglobin.
- ○ B Someone with two mutated alleles for the production of haemoglobin.
- ○ C Someone without mutated alleles for the production of haemoglobin.

c Who has the greater chance of surviving in an area with malaria?
- ○ A Someone with one mutated allele for the production of haemoglobin.
- ○ B Someone with two mutated alleles for the production of haemoglobin.
- ○ C someone without mutated alleles for the production of haemoglobin.

d Explain why sickle cell anaemia is more common in Africa than in Europe.

Go to the *Flash cards* and the *Test yourself* section.

5 The history of life on Earth

LEARNING OBJECTIVES

5.5.10 You can explain how fossils arose.
5.5.11 You can explain that species are related if they have a common ancestor.

► Practical activity 2

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES		
	5.5.10	5.5.11	5.3.6*
Remembering	2a	1a	1a
Understanding	2bc, 4	1b, 3, 4	
Using	6, 10	5, 10	
Analysing		7, 8, 9	

* You can find this learning objective in another Basics section.

All kinds of species of organisms have arisen during the development of life on Earth. There are many similarities between different species, for instance in their DNA, proteins and phenotypes.

FOSSILS

Fossils are sometimes found in rock layers. **Fossils** are remains of organisms that have turned into rock, or prints of organisms in rocks (see figure 1). Fossils arise when the remains of organisms are covered by **sediment** (layers of sand or clay particles). If this happens quickly, bacteria and fungi do not have time to break down the remains entirely. The sediments turn into rock and the fossil is preserved. Soft parts often decay too fast to fossilize. That is why fossils of shellfish are more common than fossils of worms, for example.

fig. 1 Fossils (mya = million years ago).

1 Trilobites: arthropods that lived in the sea (500 mya)

2 Archaeopteryx: a flying dinosaur (150 mya)

3 Lycoptera: fish that lived in the area that is now China (150–75 mya)

New sediments are deposited on top of older layers. The youngest rock layers are usually closest to the surface. Older rock strata are found deeper in the Earth's crust.
The fossils of some species are only found in a single rock layer, not occurring in older or younger rock layers. These species of organisms probably only lived in a certain period, after which they died out. This shows that species arose and disappeared throughout the history of the Earth. Fossils sometimes show that species change.

ERAS

The history of life on Earth is divided into eras that are further divided into periods. Figure 2 represents the eras and periods on a **geological timescale** (geology = Earth science). It shows how many million years ago each period began and ended and what life forms existed during that period. The oldest forms of life on Earth are at the bottom.

fig. 2 Geological timescale (mya = million years ago).

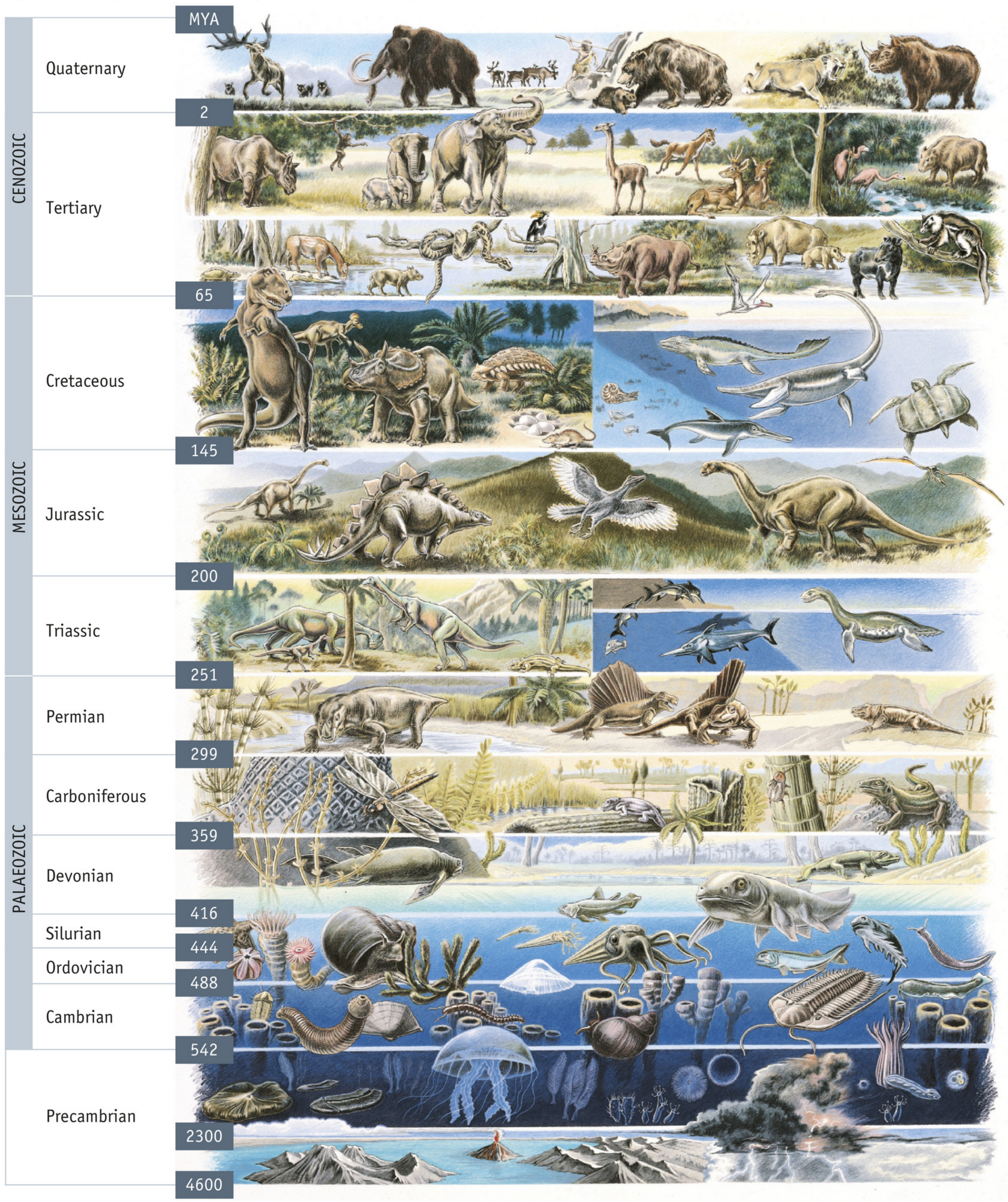
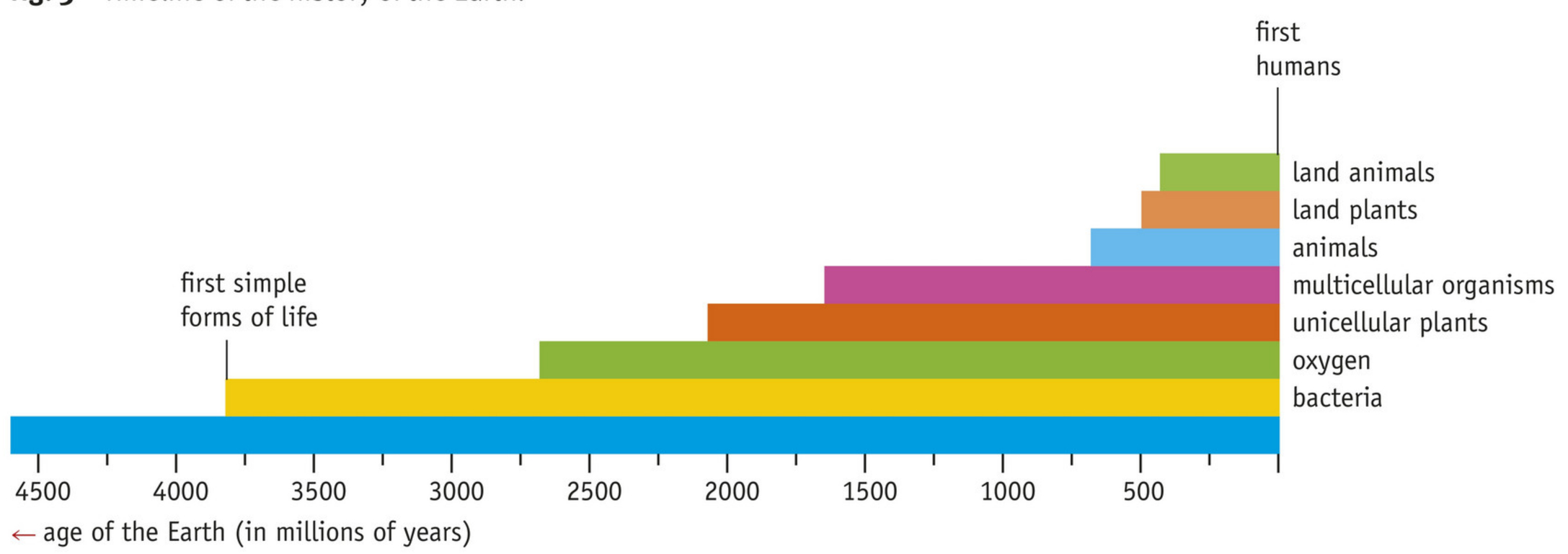


Figure 3 shows the history of the Earth on a timeline. The Earth is approximately 4600 million years old (4.6 billion years old). Life was not possible on Earth when it first existed. The temperatures were still too high then. The first simple life forms probably arose roughly 3800 million years ago. They lived in the water. At that time, the air did not yet contain oxygen. From these simple forms of life, the first bacteria arose. Some of those bacteria were able to produce oxygen.
Approximately 3300 million years ago, other single-celled organisms emerged that could photosynthesize. As a result, more oxygen was released into the water and the air. The first multicellular organisms arose roughly 1600 million years ago. The first animals appeared about 700 million years ago. All these species originated in the oceans and seas. On land, there were only bacteria.

fig. 3 Timeline of the history of the Earth.



ANIMALS ON LAND

The first land animals were mainly arthropods (centipedes in particular). They were soon followed by vertebrates – the amphibians and the reptiles. The heyday of the reptiles began approximately 251 million years ago. All kinds of dinosaurs (from *sauros* = lizard) appeared. Huge dinosaurs lived on land. All kinds of dinosaurs also lived in water and in the air (see figure 4). The first mammals and birds arose alongside the dinosaurs.

fig. 4 Extinct animals.

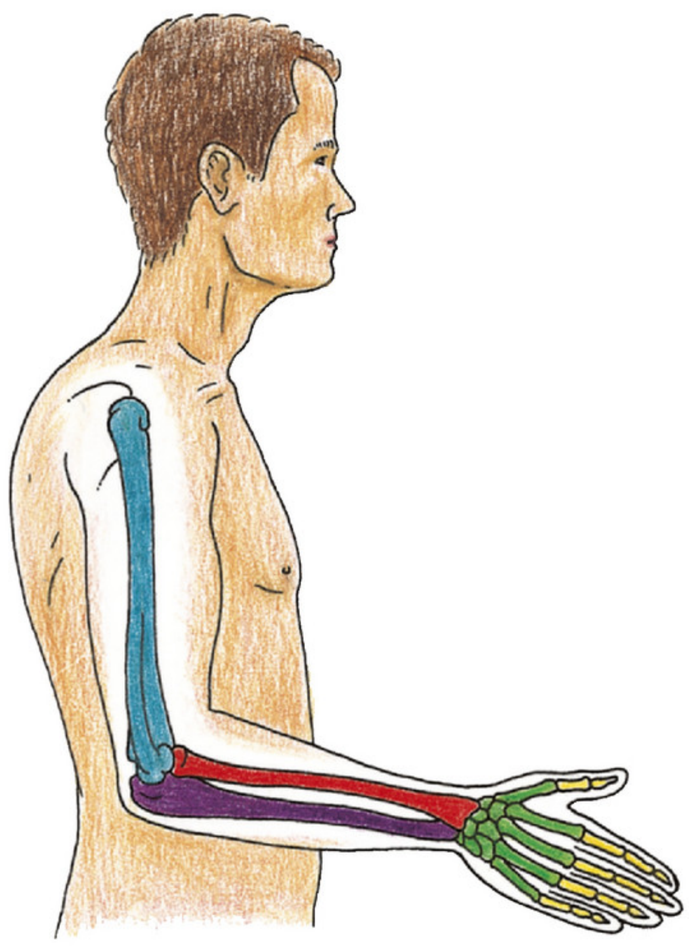
The dinosaurs died out 65 million years ago, in just a short time. This was probably due to climate change caused by a rock from space about 10 km across striking the Earth. This created a huge explosion followed by lots of forest fires. After that, black clouds of dust and soot hung over the Earth's surface for several years. There were also huge volcanic eruptions in Asia around this time. It is likely that all these dust clouds blocked so much sunlight that it became almost completely dark on Earth and temperatures dropped sharply.
The dinosaurs did not survive this climate change, but the mammals and birds did. After the black clouds had disappeared, the mammals and birds could flourish. The first primitive humanoids (creatures like humans) arose around 3 million years ago. The human species that lives now (*Homo sapiens*), originated in Africa 300,000 years ago.

KINSHIP OF SPECIES

All kinds of species of organisms have arisen during the development of life on Earth. Species that have a common ancestor are related – they have a degree of **kinship**. The more closely the DNA of the species matches, the more closely these species are related. Genes contain the information for creating proteins. If the DNA matches better, the phenotype and the proteins are also more alike. This makes it plausible that species had a common ancestor. The better their DNA, phenotype and proteins match, the more recently that common ancestor lived.

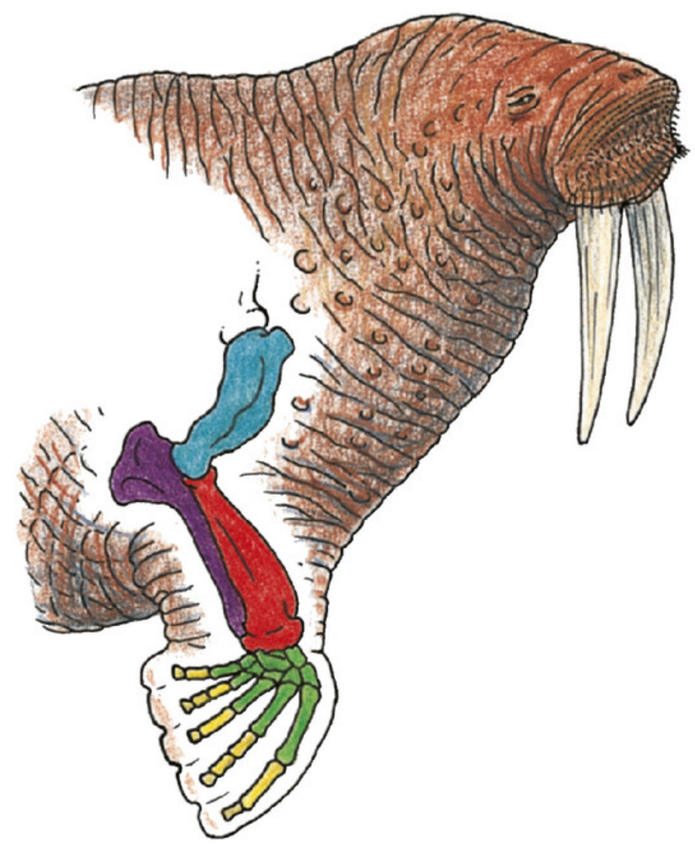
The arm of a human, the wing of an eagle and the front flipper of a walrus have different functions. Figure 5 shows the skeletons of these organs, with corresponding bones in the same colours. You can see that these organs have similar structures. These organs are most probably derived from the same original structure. These animals therefore probably have a common ancestor. Adaptation to various environments has caused the organs to have different functions.

fig. 5 Arm bones.



1 a human arm

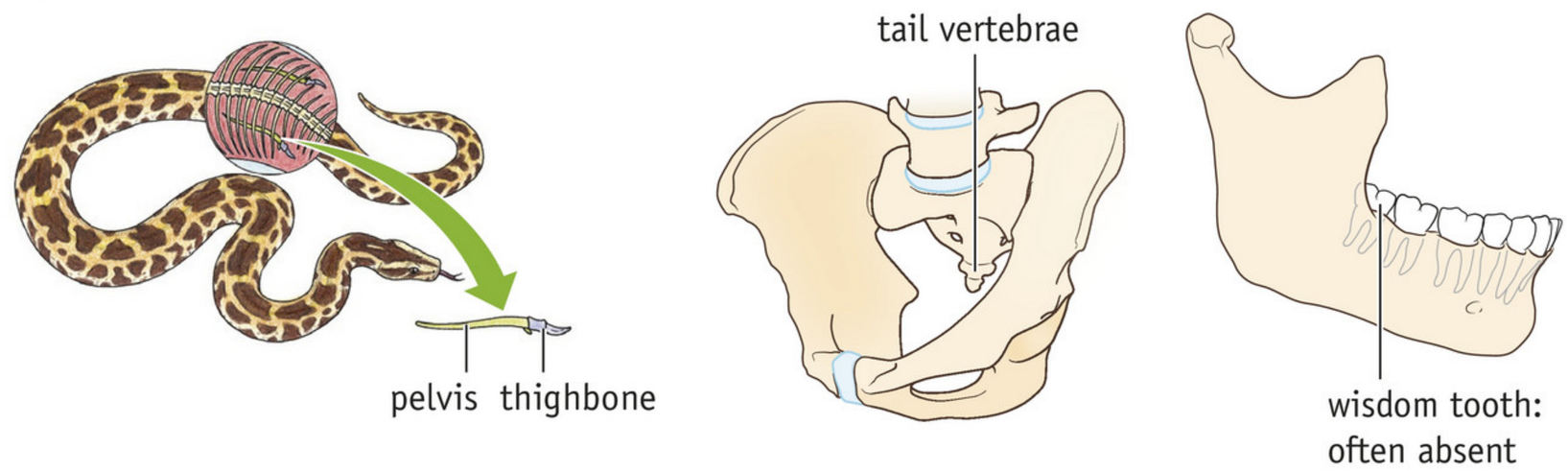
2 an eagle's wing



3 a walrus' front flipper

Adaptations can make organs lose part of their function and not develop or hardly develop at all. Sometimes remains of these organs can be found in the structure of an organism. These are called **rudimentary** or **vestigial** organs. For example, some snakes have vestigial legs (see figure 6). Examples of rudiments in humans are the tail vertebrae and wisdom teeth.
In our ancestors, wisdom teeth increased the chance of survival: a large jaw and more molars were helpful when eating food that was difficult to digest and unprocessed (raw). Today, our jaws are smaller and wisdom teeth are no longer needed. Another example is goosebumps. People get goosebumps when they are cold. If we still had fur, the cold would be making the hairs stand on end. The fur would then retain more heat. People no longer have fur, but our ancestors did.

fig. 6 Rudiments.



KNOWLEDGE

1 Researchers are still working on improving and supplementing the theory of evolution. Research is being carried out into the relationships between species that used to exist and species that are alive now. DNA studies are a very important part of this research. Using modern techniques, researchers can isolate DNA from fossil remains of up to 100,000 years old.
Here are the base pairs of a piece of DNA that comes from a fossil.

T	**C**	**T**	**A**	**G**	**C**	**G**	**A**	**T**	**T**
A	G	A	T	C	G	C	T	A	A

And these are four pieces of DNA from modern species.

a Fill in the missing bases.

Species 1

T	**C**	**G**	**A**	**T**	**C**	**G**	**T**	**T**	**T**
A	G	C	T	A	G	C	A	A	A

Species 2

A	**C**	**G**	**A**	**A**	**T**	**G**	**G**	**T**	**A**

Species 3

A	**G**	**T**	**A**	**C**	**G**	**G**	**T**	**A**	**T**

Species 4

T	**C**	**C**	**A**	**G**	**C**	**C**	**A**	**T**	**T**

b Which species is probably most closely related to the fossil?

○ A species 1
○ B species 2
○ C species 3
○ D species 4

2

a What are fossils?

b Why do fossils only occur when the remains of an organism are covered by sediments?

c Figure 7 shows four animals.
Which two animals will fossilize best after their death?

☐ A jellyfish
☐ B mussel
☐ C slug
☐ D butterfly

fig. 7

1 slug

2 mussel

3 butterfly

4 jellyfish

3

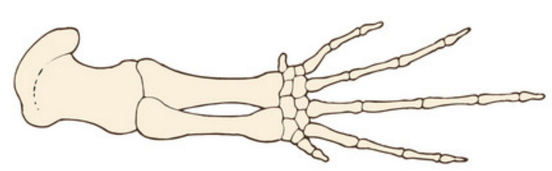
a Figure 8 shows you the arm bones of several animals. The similarities between these arm bones suggest a common ancestor.

- For each picture, say which organism the arm bones belong to. Use *human – mole – horse – bat – whale*.
- Also say what function the arm bones have. Use the following: *organ for digging – organ for grasping – organ for walking - organ for steering – organ for flying*.

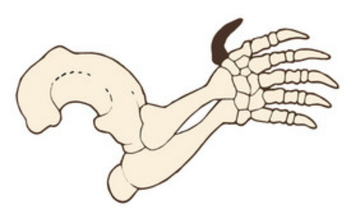
b Vestigial organs also indicate a common ancestor. The vertebral column of a human is very similar to the vertebral column of other vertebrates. The lower vertebrae of humans are vestigial.
What function did these vertebrae have in the ancestors of humans?

fig. 8 Arm bones.

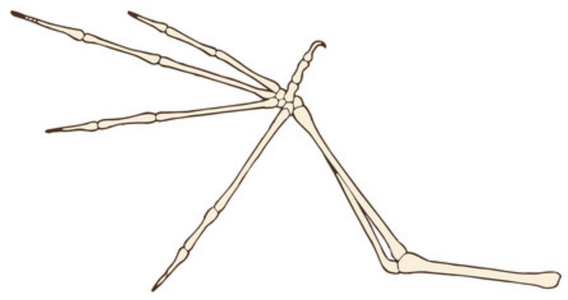
1 arm bones of a .....
function: .....

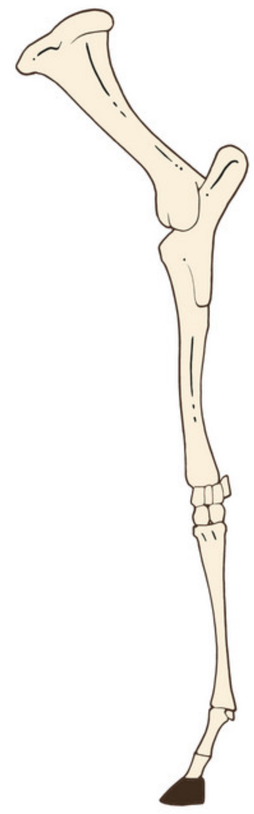


2 arm bones of a .....
function: .....



3 arm bones of a .....
function: .....





4 arm bones of a .....

function: .....

5 arm bones of a .....

function: .....

4

Summary

In your own words, explain the following concepts: fossils, kinship, family tree and rudimentary organs.

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INSIGHT

5 Figure 9 is a diagram showing the probable ancestry of organisms. This figure lets you read off which groups of organisms developed from others. It also shows you which groups have a close degree of kinship and which groups are less closely related. Finally, you can read off which groups were flourishing in which periods. These groups are drawn with a broader line then.

a Which group of organisms has become completely extinct? .....

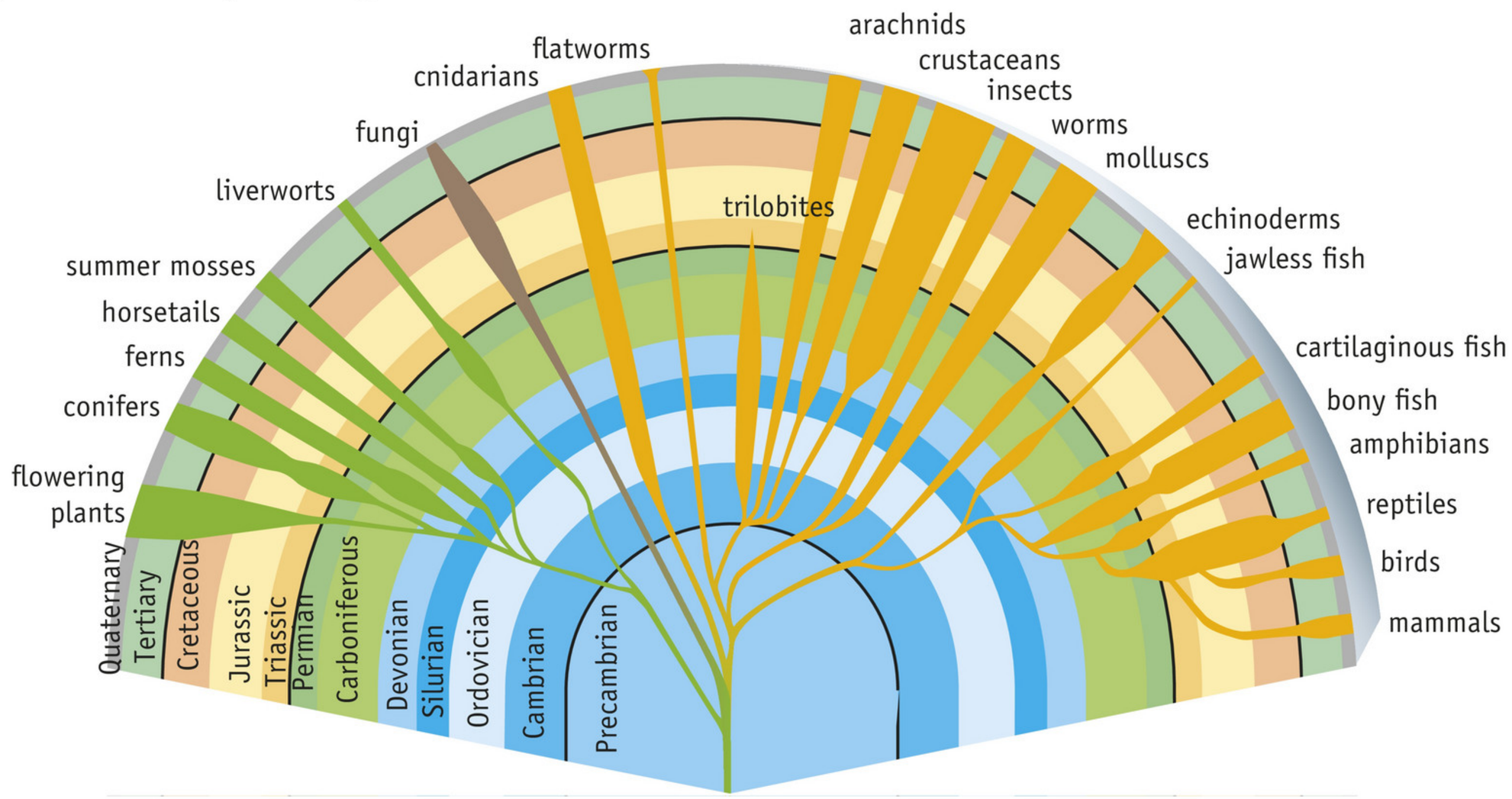
b This group became extinct in the *Jurassic* / *Permian* / *Triassic* period.

c What two groups developed from the reptiles?

- ☐ A amphibians
- ☐ B bony fish
- ☐ C cartilaginous fish
- ☐ D birds
- ☐ E mammals

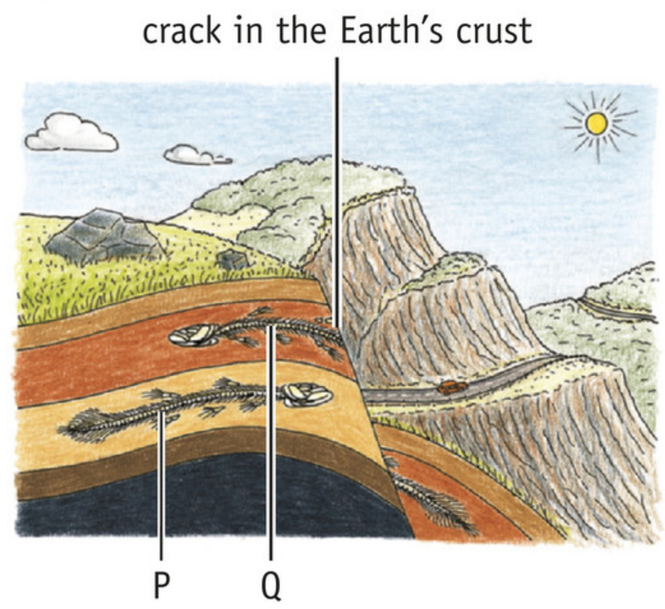
d Ferns, horsetails and mosses are spore-bearing plants.
In what order did these groups appear? Write down the oldest group first.

fig. 9 Probable family tree of organisms.



6 **a** Figure 10 shows two fossils marked P and Q. Fossils like Q are easier to find than fossils like P.
Give two reasons why.

fig. 10

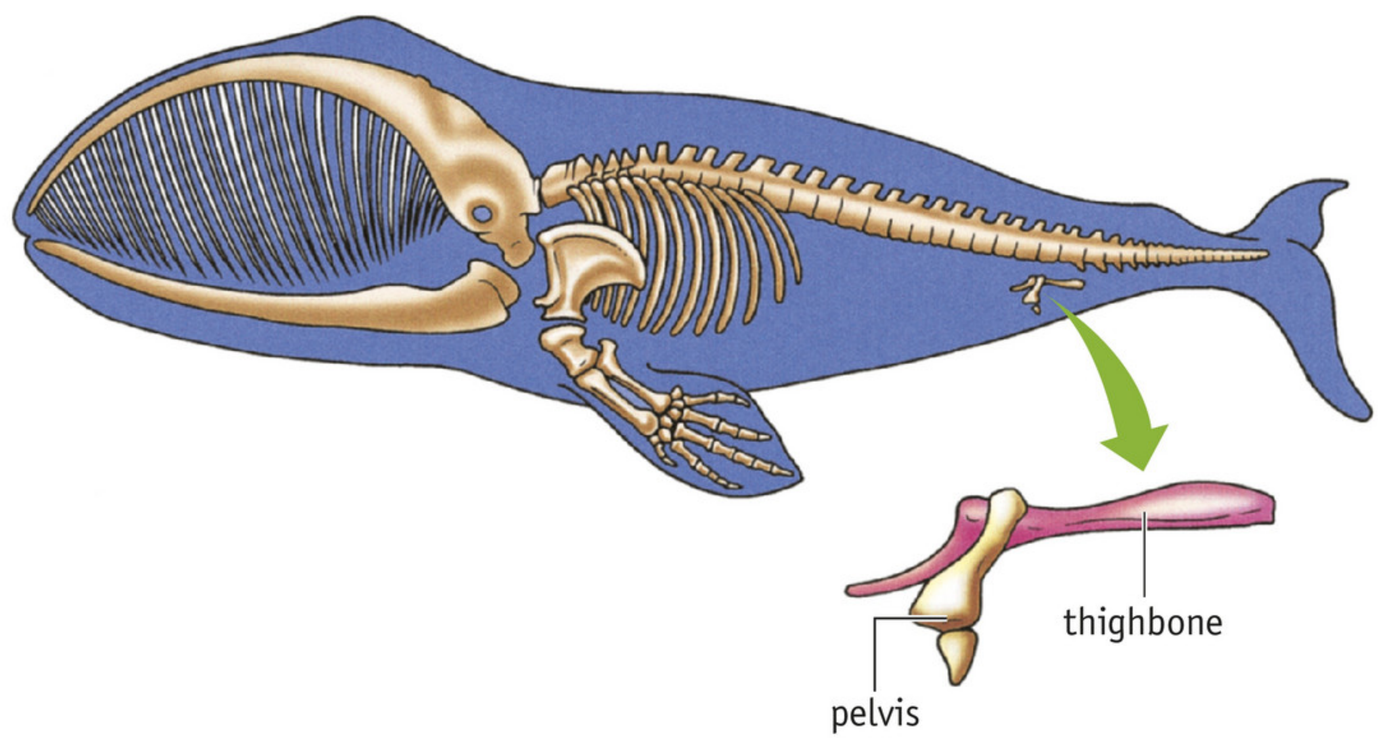


b There can be various reasons why the order of rock layers may have changed over time. Sometimes you can tell the age of a rock layer by the fossils that are found in it. Which fossil is most suitable for determining the age of a rock stratum?

- ○ A The fossil of an organism that occurred at many places on the Earth for just a short period.
- ○ B The fossil of an organism that occurred in very few places on the Earth for just a short period.
- ○ C The fossil of an organism that occurred in many places on the Earth over a long period.
- ○ D The fossil of an organism that occurred in very few places on the Earth over a long period.

7 Figure 11 shows the skeleton of a whale. You can see a hip bone and thigh bone where the tail begins. Scientists thought for a long time that these bones had no purpose but they are in fact essential: the attachment muscles of the penis are connected to them. So the unattached bones are still needed when mating.
Are the whale's hip bone and thigh bone rudiments? Explain your answer.

fig. 11 Whale with hip and thigh bones.



8 You can determine how closely species are related by comparing characteristics. You will have to look at a large number of characteristics to make a reliable statement.
Table 1 shows comparisons of fifteen characteristics for four species. A characteristic that is present is marked with +; a missing characteristic gets a –.

Table 1 Comparisons of fifteen characteristics.

Reference	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Species 1	+	+	+	–	+	+	+	–	–	–	–	–	–	–	–
Species 2	–	+	–	+	+	–	+	+	–	–	–	–	–	–	–
Species 3	–	–	–	–	–	–	+	+	+	+	+	–	–	–	–
Species 4	–	–	–	–	+	–	–	+	–	+	–	–	–	–	–

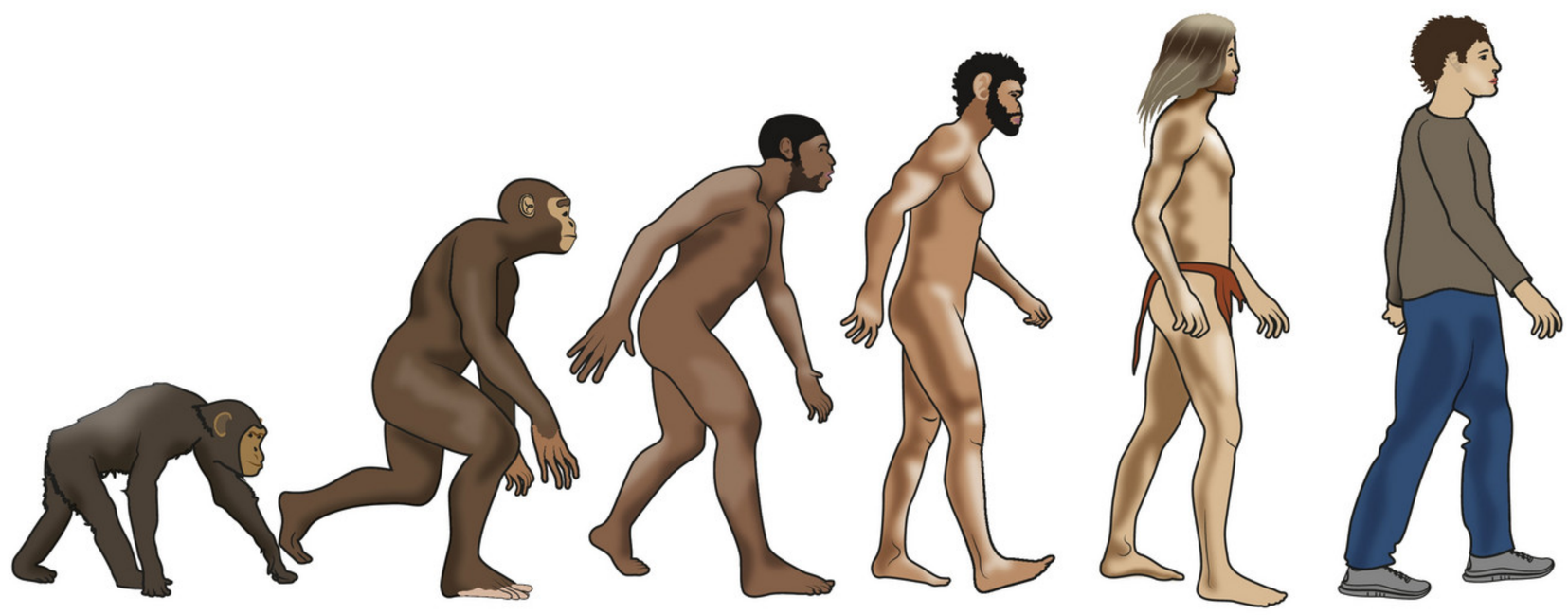
Which two species are most closely related?

species ..... and species .....

+ 9

Figure 12 is a schematic representation of human evolution. *Homo erectus* was one of the ancestors of modern humans. This ancestor was the first human that walked upright. Ancestors of *Homo erectus* were four-footed (quadrupeds).
What characteristic of the human spine makes it easier to walk upright?

fig. 12



HOW IT FITS TOGETHER science

HOMO FUTURIS

In the past, humans were constantly adapting to changing circumstances. The individuals who were best adapted to the conditions stayed alive and had the most opportunity to reproduce and raise children. That adaptation to the conditions never stops. People who live in high mountain ranges have genetic changes that let them breathe better in thin air, for example, and members of an Asian people called the Bajau, who are underwater fishermen, have an enlarged spleen that provides more oxygen in the blood. The different structure of their spleen is a result of a recent change in a gene.
Evolution will continue in the future. People may perhaps get weaker immune systems due to the use of medicines. The fact that a lot of manual work will be taken over by machines or robots might affect the muscle strength of people in the future. External characteristics such as skin colour may change, as people from all parts of the world have spread over the Earth and formed mixed relationships with each other. Hearing aids, glasses and contact lenses let people survive who might not have been able to do so in prehistoric times. As a result, our eyes and ears may be getting worse.
In short, evolution never stops. People who are best adapted to cultural and technological developments will benefit from this. What do you think humans will look like in 10,000 years?

fig. 13 Is this *Homo futuris*?

10 Read the text '*Homo futuris*'.
The ancestors of modern man had a different way of life.

a Make a list of activities that prehistoric people did but modern people no longer do.
b Make a list of activities that modern people do but prehistoric people did not.
c Think about what characteristics people may no longer need in the future and what characteristics might become more important. Put them in the table.

Characteristics that are less important in the future	Characteristics that are more important in the future

d Which organs do you think might be rudimentary in *Homo futuris*?
e Which characteristics would still show that *Homo futuris* is descended from modern man?
f Draw your homo futuris.

Go to the *Flash cards* and the *Test yourself* section.

6 DNA techniques

LEARNING OBJECTIVE

5.6.12 You can describe various DNA techniques in biotechnology.

► Learning how to do research 1

TAXONOMY	LEARNING OBJECTIVE AND EXERCISES
	5.6.12
Remembering	1
Understanding	2, 3, 4
Using	5, 6ac, 7, 8, 9
Analysing	6b

People use organisms to manufacture products. Thanks to all kinds of new DNA techniques, biotechnology is developing rapidly.

GENETIC MODIFICATION

Biotechnology is the collective name for technology that uses organisms to make products for humans. Simple examples are yeasts to make bread rise and bacteria to make yoghurt. The organisms used are capable of producing the desired substances by themselves. The DNA of the organisms does not need to be changed.

In newer forms of biotechnology, the DNA of organisms does get changed. There are various techniques for introducing new hereditary information into the DNA of an organism. A collective name for these techniques is **recombinant DNA techniques**. The new DNA may come from another species of organism.
One example is the production of insulin. Diabetes patients must inject a certain amount of insulin daily. In the past, insulin was made from the pancreases of slaughtered pigs. That was expensive and time-consuming. Healthy people have a gene that contains the information for producing insulin. Bacteria do not have this gene. The DNA from this gene was taken from human cells and introduced into bacteria. As a result, those bacteria can produce insulin. Insulin is now pure and cheap.

Adding desired genetic characteristics to organisms is called **genetic modification**. Genetically modified organisms are referred to as **transgenic**. As well as microorganisms, plants and animals are also often modified genetically. Genetically modified organisms are used in healthcare, agriculture, industry and the environment.
Figure 1 shows some applications of genetic modification.

fig. 1 Genetic modification.

Apple trees without scab

Researchers at Wageningen University have introduced a gene from barley into the genotype of apple trees. The gene from barley contains the information for producing a substance that protects against fungi. Genetically modified apple trees are now much more resistant to the damage caused by the fungal disease called scab and fewer pesticides are needed.

Stonewashed jeans

In the past, jeans were washed in a large washing machine with pumice stones to give them a stonewashed look. That took a lot of energy and time. Nowadays, the process is much cheaper and faster due to treatment with the enzyme cellulase, produced by genetically modified bacteria.

Disease-free potatoes

The parasite *Phytophthora infestans* causes potato blight in potatoes (and tomatoes). Under favourable conditions, the infection can spread within a couple of days. The crop is then lost. Genes from bees and moths have been introduced into potato plants, protecting the crops from potato blight.

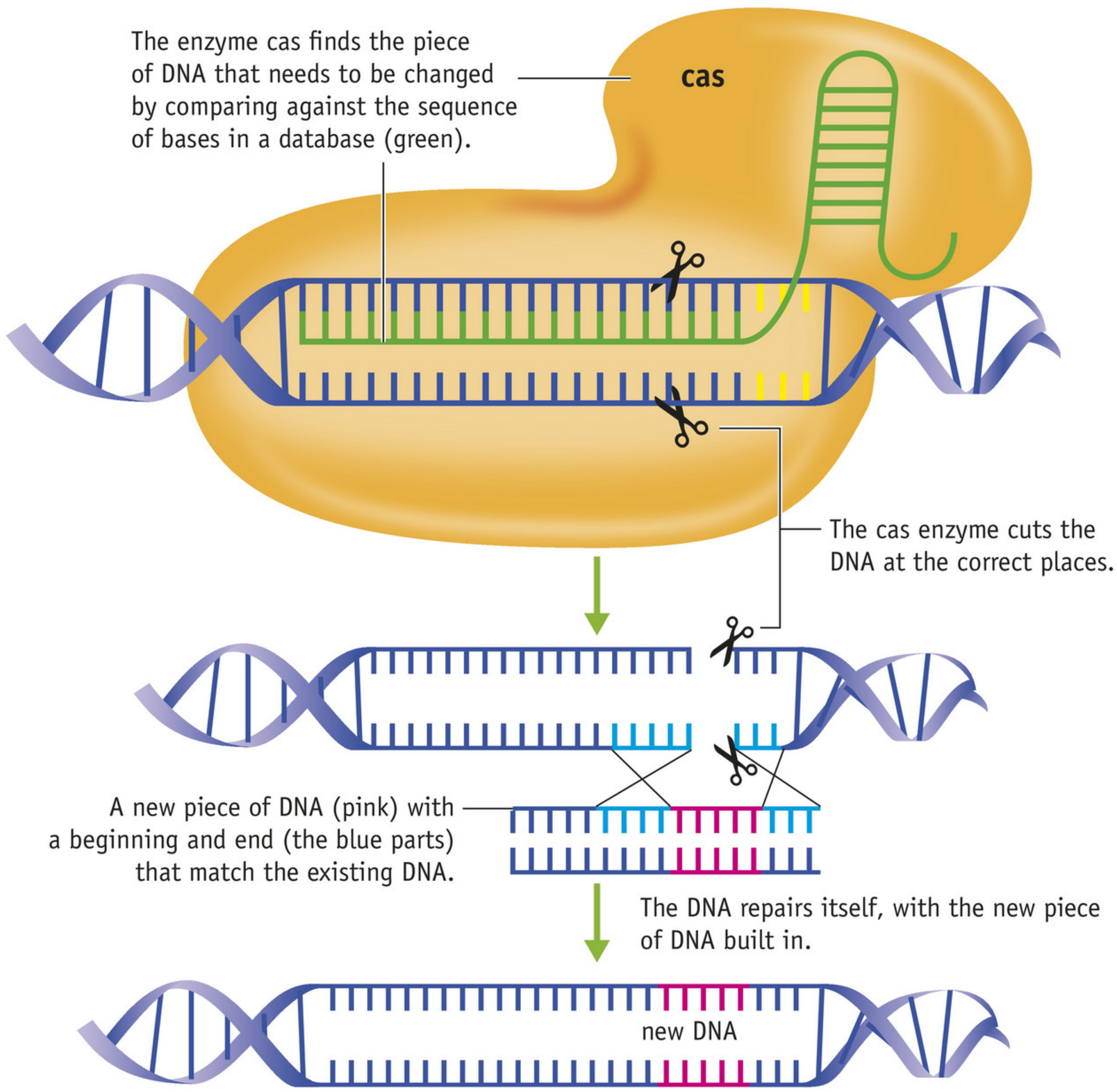
Golden rice

Golden rice is a rice variety that a gene from maize has been built into. The rice grains then produce beta-carotene, a substance that can be converted in the body into vitamin A. Golden rice has been developed to help children with vitamin A deficiency. Not enough of this vitamin can cause blindness. The beta-carotene colours the rice yellow (which is why it is called ‘golden rice’).

CRISPR-CAS

Using of genes from other species is likely to be largely replaced before long by a new technique called **CRISPR-Cas**. In CRISPR-Cas, targeted changes are made in an organism’s existing genes. This is called **gene editing**. The technique can be compared with modifying a text (editing). Changing a few letters or removing a word creates a word or phrase with a new meaning.

fig. 2 Editing genes using CRISPR-Cas.



CRISPR-Cas is a mechanism that bacteria use as a defence against viruses. If a bacterium survives a virus attack, it can store the viral DNA in a kind of 'database' in its cell. An enzyme called Cas continuously monitors the bacterium for the presence of viral DNA by comparing it against the DNA in the database. When the enzyme finds viral DNA, it cuts it up to destroy it.

Scientists are now using the same mechanism to modify genes in organisms. Cas is inserted to find the piece of DNA that needs to be changed. The enzyme cuts that piece of DNA out. The ends can then be glued together or a new piece of DNA can be inserted. This makes it possible to switch off or replace a gene. Figure 2 is a schematic drawing of this technique.

In healthcare, CRISPR-Cas is used for gene therapy. **Gene therapy** is using gene editing techniques to repair damaged genes. Figure 3 shows some applications of gene editing.

fig. 3 Gene editing.

Chocolate
Scientists are working on a solution for strengthening the cocoa plant's immune system. This will make the plant resistant to a virus that has had a massive effect on West African crops.

Bananas
Scientists are trying to change genes to create bananas that are more resistant to a certain fungus.

Coffee
Scientists have adapted genes from a coffee plant so that the beans no longer contain caffeine. This is cheaper and better for the taste than removing the caffeine at the factory.

Rice
Scientists have developed a rice variety that produces 25 to 30% more rice grains, while the plant can still withstand heat and drought just as well.

Tomatoes
Geneticists found thirteen flavour compounds in an old tomato variety. They might add these flavours to modern varieties to give tomatoes more taste.

Maize
Scientists have discovered a gene in a native maize species that makes more maize kernels form under dry conditions. Scientists want to add this gene to modern varieties too.

Mushrooms
At Pennsylvania State University, scientists discovered that the unwanted brown spots on some mushroom species are the result of a gene. Editing this gene will let mushrooms be stored for longer and look better.

Wheat
Scientists in Spain and America are adapting a wheat variety so that the wheat grains will contain much less gluten. This is good news for people who are gluten-intolerant.

DISCUSSION

Most applications of genetic modification (GM) are in food production (see figure 4). There are opponents and supporters of GM. Table 1 gives some of the arguments.

fig. 4 Vegetable oil with genetically modified soya.

Table 1 Arguments for and against genetic modification.

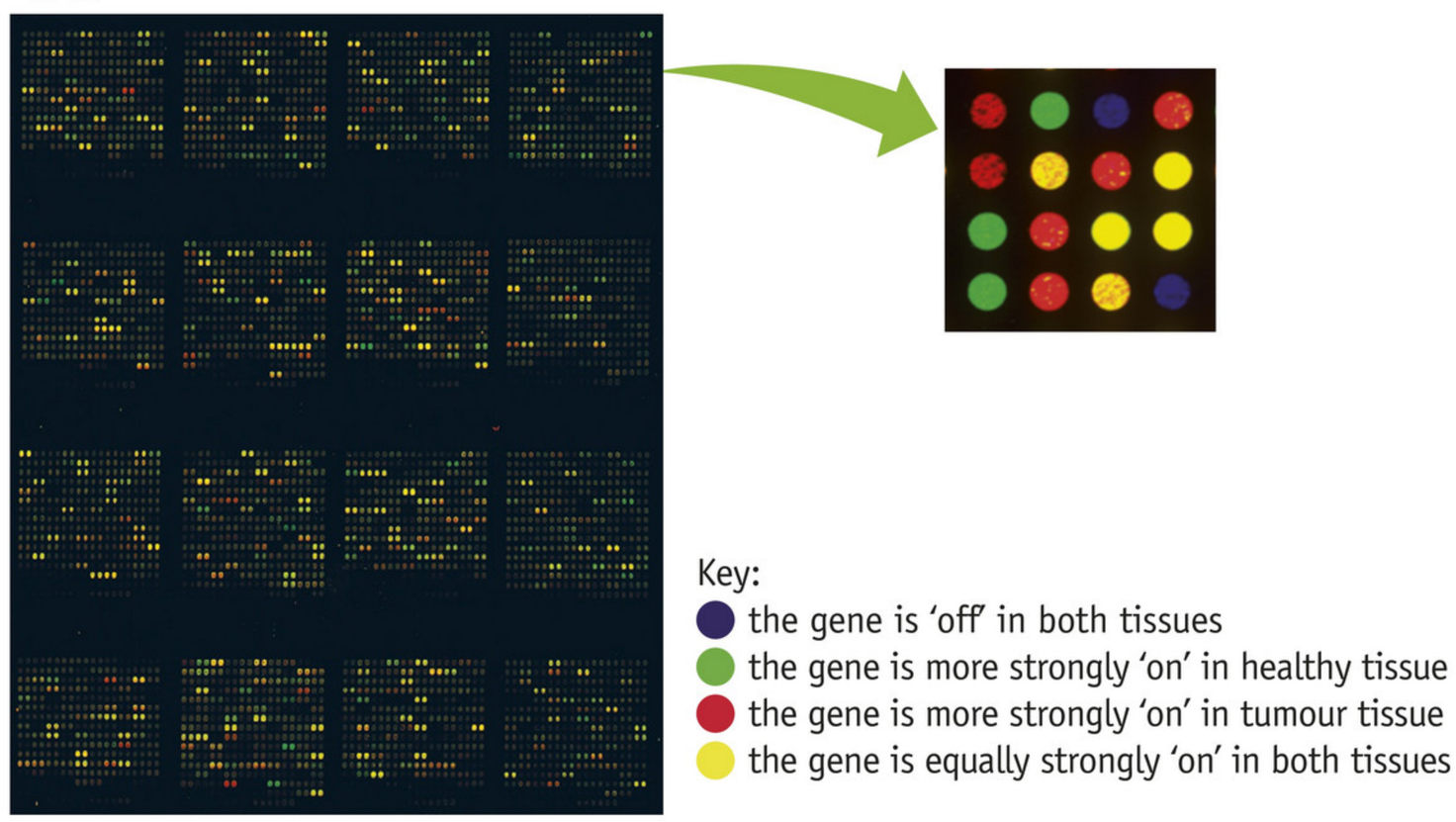
For	Against
The food yield increases. This is needed for feeding the growing world population.	Humans do not have the right to change the genetic characteristics of organisms as they see fit.
Some crops can be made resistant to diseases, which means less chemical pesticides are needed.	Some crops can be made resistant to chemical pesticides, which means more of the pesticide can be used.
People already 'improve' plants and animals by cross-breeding them (selecting favourable characteristics); genetic modification does the same but more quickly.	Genetic modification means that all kinds of new organisms can be 'created' at will.
Genetic modification helps to produce medicines better, faster and more cheaply.	The variation within a species can be reduced because farmers only use a few genetically modified varieties.
Fruit and vegetables can be made healthier (with more nutrients) and tastier.	Genetically modified organisms can end up in the environment and spread; we do not know what the consequences might be.

GENOMICS

Genomics is the study of the entire DNA of an organism and all the genes it contains. Genomics is used in cancer research, for example. In cancer research, researchers study the activity of many genes at the same time. They compare the activity of genes in healthy tissue and tumour tissue. Using a special technique, they can visualize which genes are switched on or off in tumour tissue and healthy tissue (see figure 5).

Genomics makes it much easier to detect diseases. A doctor does not then need to test a patient for disease 1, disease 2, disease 3, etc. to find out what is wrong: they can compare the DNA with that of healthy individuals. They can then quickly spot any abnormalities.
Genomics is also used to tailor treatments and medication to a specific patient.
In cattle breeding, genomics is used to select favourable genotypes for breeding bulls.

fig. 5 Genomics in cancer research.



DNA TESTS

DNA tests are cheap, fast and accurate. That is why DNA tests are now used in the fight against crime, for example. Each one of us has their own unique DNA. If flakes of skin, hairs, semen or blood traces are found at the scene of a crime, the DNA from the cells can be tested and compared against the DNA of suspects. This can allow the real perpetrator to be unmasked from among a group of suspects.
DNA tests can also be used in many other areas, for example to detect meat fraud. DNA tests can show what species of animal the meat comes from. For example, one meat supplier was caught selling horse meat (which is cheap) as beef (which is more expensive).
DNA tests can also be used to detect hereditary diseases. And DNA tests can show the evolutionary kinship between species or define a new species. DNA kinship research can be used to determine whether a man is the biological father of a particular child.

eDNA

Analysing **eDNA** (environmental DNA) is a promising technique. This is the DNA collected in a certain environment, for example from a litre of seawater or a spadeful of snow. All organisms leave unique DNA traces by pooping, leaving mucus, losing dead skin cells, and so on. Scientists can use eDNA to find out what species there are in the area without having to catch the actual organisms. They compare the eDNA found with pieces of DNA in a database that contains the DNA of known species. If there is a match, that species has probably been in the area.

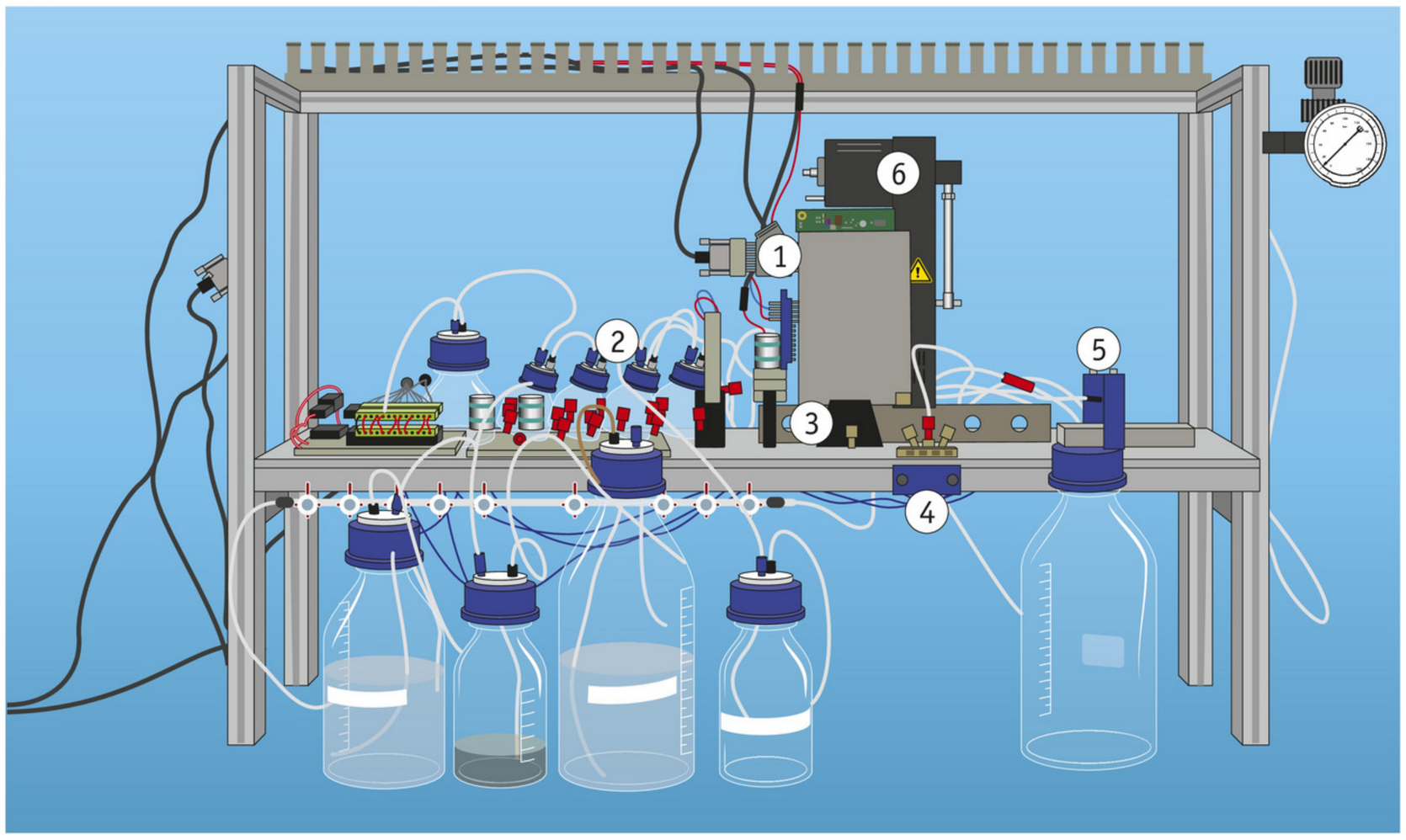
SYNTHETIC BIOLOGY

Synthetic biology is a field in which biological material is artificially recreated. DNA can also be artificially recreated. For example, scientists have already replaced the complete DNA of a bacterium with artificially made DNA. The other organelles and cell structures of the bacterium remained unchanged. The bacteria remained alive and reproduced slowly. They do have an abnormal shape. Synthetic biologists hope that in future they will be able to design DNA for microorganisms that can clean up waste or produce biofuels.

Another application of artificial DNA is information storage. Manually embedding information in DNA has been possible for a while, but in 2019 it was completely automated for the first time. Microsoft built an automated system that stored the word ‘HELLO’ (five bytes) in DNA (see figure 6). This took about 21 hours.

In the future, synthetic DNA may be the way to store much more data in much less space than is now possible with the best computer technology. All the computer data in the world would fit in one kilogram of DNA!

fig. 6 Automated data storage as DNA.



1 Computers translate the word HELLO from bytes into a code made up of A, C, T and G.
2 A DNA synthesizing module assembles the molecule.
3 The DNA created is put in a bottle.
4 A device prepares the DNA for analysis.
5 A module reads the base sequence.
6 A computer translates the code back into the word HELLO.

KNOWLEDGE

1 Select the correct term for each description.

A	making changes to the genotypes of organisms	○	○ 1 biotechnology
B	techniques where organisms are used to make products for humans	○	○ 2 genetic modification
C	collective name for all the techniques used for changing the DNA of organisms	○	○ 3 recombinant DNA techniques

2 Here are some arguments that are used in discussions about genetic modification.
For each argument, say whether it is used by people who are for genetic modification or against it.

- Treatments of some diseases can be better and cheaper. *for / against*
- The quality of food can be improved. *for / against*
- Modifying animals can affect their welfare. *for / against*
- Crops can be developed that are more resistant to climate change. *for / against*
- Genetically modified organisms can end up in nature and cause damage there. *for / against*
- Growing genetically modified crops is less labour-intensive, so people may lose their jobs. *for / against*

3 A bull has produced several calves that have developed into excellent dairy cows. These cows give more milk than average. The breeder wants to find out which male offspring can pass on this characteristic in the future. Those male calves could then be sold for a lot of money. Genomics is used to determine which male calf is best suited as a breeding bull. The DNA sequence for this characteristic is shown here. (Very simplified: in reality, thousands of base pairs are needed for each characteristic!)

DNA of the breeding bull

A	**T**	**T**	**C**	**G**	**G**	**T**	**A**	**A**	**C**	**T**	**G**	**T**	**A**
T	A	A	G	C	C	A	T	T	G	A	C	A	T

DNA of calf 1

A	**T**	**T**	**C**	**G**	**G**	**T**	**A**	**A**	**T**	**C**	**C**	**T**	**A**
T	A	A	G	C	C	A	T	T	A	G	G	A	T

DNA of calf 2

A	**T**	**T**	**C**	**G**	**G**	**T**	**A**	**A**	**C**	**T**	**C**	**T**	**A**
T	A	A	G	C	C	A	T	T	G	A	G	A	T

DNA of calf 3

A	**T**	**T**	**C**	**G**	**G**	**T**	**A**	**A**	**C**	**T**	**G**	**T**	**A**
T	A	A	G	C	C	A	T	T	G	A	C	A	T

DNA of calf 4

A	**T**	**A**	**C**	**G**	**G**	**T**	**T**	**A**	**C**	**T**	**G**	**C**	**A**
T	A	T	G	C	C	A	A	T	G	A	C	G	T

a Which calf is the most suitable as a breeding bull?

- ○ A calf 1
- ○ B calf 2
- ○ C calf 3
- ○ D calf 4

b Is the calf selected through genomics a transgenic animal? Explain your answer.

4 **Summary**

Here is a list of terms. Write down what you need to know about each term.

- Biotechnology

.....

.....

.....

.....

- Genetic modification

- Recombinant DNA techniques

- CRISPR-Cas

- DNA test

- Genomics

- eDNA

- Synthetic biology

INSIGHT

5 CRISPR-Cas allows the characteristics of an organism to be changed. In modified bacteria, the chances that the offspring will also get those altered characteristics are higher than in humans.
Explain why.

6 Malaria is a disease that is transmitted by mosquitoes. Scientists in California have created a mosquito species with a special gene. This gene ensures that mosquitoes can no longer infect humans with malaria. The gene was introduced into the DNA using the CRISPR-Cas technique. Of course, not all mosquitoes can be given the new gene this way.

a Explain how a small number of modified mosquitoes could help in the fight against malaria.

b In nature, natural selection plays an important role in the adaptation of a species. Explain why introducing genetically modified mosquitoes is not sufficient to combat malaria.

c Give one argument for and one against this way of fighting malaria.

7 Haemophilia is a hereditary disorder in which the blood does not clot properly. In haemophilia, the liver cells cannot produce certain proteins. That is because of a small error in the DNA.
Researchers think they can help people with haemophilia with gene therapy. In the laboratory, the right piece of DNA is introduced into a virus. The virus is administered in the arm via an infusion. The virus delivers the DNA piece to the liver cells. After that, the liver cells work properly again.

a In this treatment, only the liver cells get the right piece of DNA.
Explain why the DNA in the other body cells does not need to be repaired.

b Explain why researchers use a virus that cannot multiply.

c The researchers expect that this treatment will need to be repeated after several years.
Explain why the treatment needs to be repeated.

d Haemophilia is a hereditary disease.
Explain whether the treatment can prevent someone with haemophilia from passing the disease on to their offspring.

8 Argue the case for or against genetic modification for a web forum. Use the instructions in figure 7.
When you argue the case, explain whether you agree or disagree with the following statement: "Genetic modification is needed for the future of mankind."

fig. 7

Arguing a case

1. Collect arguments for and against the proposition.
2. Make up your own mind about the proposition (decide whether you are for or against it). Try to make a case that convinces others of your opinion. When arguing your case, you give three arguments that underpin your opinion.
3. Your case should be argued in three parts: the introduction, the core arguments and the conclusion.
4. The introduction contains three to four lines. This is where you describe what the case is about. Finally in the introduction, you give the statement that you are going to defend.
5. The core arguments section consists of about twelve to eighteen lines. This is where you give the three arguments you will use to convince others of your opinion. You should start each argument on a new line. Every argument you give starts with 'Firstly', 'Secondly', 'Thirdly' and so on.
   In the last part of the core argument, you write down a counter-argument that goes against your arguments. You then explain why this counter-argument does not outweigh all the arguments that support your position. Start this final part of the core argument with 'Finally'.
6. The conclusion contains three or four lines. Start the first sentence under the heading 'Conclusion' with 'In short' and then give your opinion again with the three arguments.

HOW IT FITS TOGETHER biology in professional life

FORENSIC INVESTIGATOR

Suppose a 15-year-old boy was stabbed with a knife in a fight. The police found a hair at the scene of the fight. In the shrubs, the police found a knife with a bloody handle. The hair and the knife were put in special bags with tweezers. The police sent this evidence to the Netherlands Forensic Institute (NFI), where it was examined by Emma, one of the forensic researchers working at the laboratory. Emma specializes in DNA investigations and she will examine the knife and hair. The information from her examinations is passed on to the police. The police use that data to determine whether someone is a suspect or not, so the information must be very reliable. That is why Emma always works with a colleague who checks if her conclusions are correct.
Many of the institute's staff have a vocational or university education, for example in subjects such as biology, chemistry, mathematics and medicine. Emma has done forensic research training at a university of applied sciences. Might a forensic investigator be the right job for you?

fig. 8 Collecting evidence at a crime scene.

9 Read the text 'Forensic investigator'.

a Explain why testing eDNA is important in solving crimes.

b The NFI has a DNA database. It stores DNA from people who have been sentenced to at least four years in prison.
If DNA is found at the crime site that is not present in this database, a suspect cannot always be traced. In some cases, a DNA kinship test is performed. DNA is taken from people in the vicinity of the place of the crime. That is compared against the DNA trace.
Here are some DNA sequences. The first DNA sequence is from a DNA trace. The others have the corresponding DNA sequence of four people from the suspect's environment.

DNA trace

T	**C**	**G**	**A**	**A**	**T**	**C**	**T**	**G**	**A**	**C**	**T**	**G**	**G**	**T**	**A**	**A**	**C**	**T**	**G**
A	G	C	T	T	A	G	A	C	T	G	A	C	C	A	T	T	G	A	C

Ahmed

A	**C**	**C**	**A**	**T**	**C**	**C**	**T**	**C**	**A**	**C**	**A**	**G**	**A**	**T**	**T**	**A**	**C**	**T**	**G**
T	G	G	T	A	G	G	A	G	T	G	T	C	T	A	A	T	G	A	C

Dirk

T	**G**	**A**	**A**	**T**	**G**	**C**	**A**	**G**	**T**	**C**	**A**	**G**	**C**	**T**	**A**	**T**	**C**	**C**	**G**
A	C	T	T	A	C	G	T	C	A	G	T	C	G	A	T	A	G	G	C

Johan

T	**C**	**G**	**T**	**A**	**T**	**C**	**T**	**T**	**A**	**C**	**T**	**G**	**G**	**C**	**A**	**T**	**C**	**T**	**G**
A	G	C	A	T	A	G	A	A	T	G	A	C	C	G	T	A	G	A	C

Michiel

C	**C**	**A**	**A**	**A**	**T**	**C**	**A**	**G**	**A**	**C**	**T**	**T**	**G**	**A**	**A**	**T**	**C**	**G**	**C**
G	G	T	T	T	A	G	T	G	T	G	A	A	C	T	T	A	G	C	G

c Who is the suspect probably most closely related to?
- ○ A Ahmed
- ○ B Dirk
- ○ C Johan
- ○ D Michiel

d The NFI database contains material of about 250,000 people. Some people think that the database needs to be expanded. Other people are against that idea.
Do you think it is a good idea to store the DNA of all Dutch people in the DNA database? Give one argument for and one against expanding the database.

e Would you like to be a forensic investigator? Say why or why not.

Go to the *Flash cards* and the *Test yourself* section.

How it fits together

TAMPERING WITH GENES CREATES MIRRORED SNAILS

All people have their heart on the left, right? Not quite! In about 1 out of every 10,000 people, the organs are mirrored and the heart is on the right. Scientists have now managed to do the same with a snail.

PARTNER DOES NOT FIT

In nature, most great pond snails (*Lymnaea stagnalis*) have a shell that spirals to the right, clockwise (as seen from the top of the shell). You can check that for yourself; you'll probably find some in the nearest ditch. If you're lucky, you might also find one with the shell that spirals anticlockwise, to the left. Pond snails with left-handed shells are rare, but you find one occasionally. These pond snails do not only have left-handed shells: their heart and liver are on the other side too. And not unimportantly, the openings of the anus and penis or vagina in left-hand spiral snails are on the left side of the neck instead of on the right-hand side. In the wild, this means that mirrored snails have a lot of difficulty finding partners because they can only reproduce with another left-hand spiral snail.

fig. 1 A right-hand spiral pond snail.

MIRRORING SNAILS

Scientists have already succeeded in creating mirrored snails by switching the cells of snail embryos around between the four-celled and eight-celled stages using glass rods. The descendants of those mirrored snails turned out to have shells that spiral to the right again.

Two Japanese scientists have now mirrored snails in such a way that their offspring also have left-hand spiral shells. They did this by tinkering with the DNA using the brand new CRISPR-Cas technique.
The scientists used the Cas scissors to cut out a gene of 3261 consecutive base pairs called Lsdia1. The result: a broken Lsdia1 gene, which meant that the protein formin was no longer produced in the snail embryos. Only snails with the broken Lsdia1 gene in both alleles had left-hand spiral shells. Their offspring also all had shells that spiralled to the left. The scientists are trying to use these results to get a better understanding of mirrored organs in humans.

Who knows – in the future, left-hand spiralled pond snails might turn up in a pet shop. Did you know that you can keep pond snails as pets in an aquarium? They are economical pets because they convert food into bodyweight six times more efficiently than pigs – and they eat their own poo.

Source: www.sciencenews.org.

EXERCISES

1

a The great pond snail is *asymmetric* / *bilaterally symmetrical* / *radially symmetrical*.

b Which characteristics of a pond snail with a shell that spirals to the left are part of its phenotype?

- ☐ A anus on the left
- ☐ B heart on the left
- ☐ C left-hand spiral shell
- ☐ D kidneys on the left
- ☐ E penis on the left
- ☐ F vagina on the left

2

To create left-hand spiral snails, scientists tinkered with the Lsdia1 gene.

a Is Lsdia1 the only gene that plays a role in making the snail's shell? Explain your answer.

b Why should you not call Lsdia1 'the gene for a right-hand spiral snail shell'?

c Say why you cannot call a broken Lsdia1 gene 'the gene for a left-hand spiral snail shell'.

3

Scientists used two methods to create left-hand spiral snails: by switching cells around using glass rods and by using CRISPR-Cas.

a Is the change made using the glass rods a hereditary change? Explain your answer.

b Is the change made using CRISPR-Cas a hereditary change? Explain your answer.

c What form of CRISPR-Cas did the scientists use? *changing letters* / *deleting a word*.
This made the Lsdia1 gene *active* / *inactive*.

d At what stage of development did the scientists apply CRISPR-Cas?
at the *1* / *2* / *4* / *8* / *16* cell stage

e The great pond snail has 36 chromosomes per cell.
In how many of these chromosomes did the mutation have to be made? Explain your answer.

4

a Is the left-hand spiral shell a new characteristic for pond snails made by the CRISPR-Cas procedure? Explain your answer.

b When compared to snails with right-hand spiral shells, do the cells of left-hand spiral snails contain new information ?

c In the wild, left-hand spiral snails have a lot of trouble finding a partner. On the other hand, they are at less risk of being eaten. This is because snakes have trouble fitting left-hand spiral snail shells in their mouths.
A left-hand spiral snail in the wild has a *higher* / *lower* chance of survival and a *higher* / *lower* chance of reproducing.

d The snails with a left-hand spiral shells could become a new species.
Explain when that is the case.

e Is making left-hand spiral pond snails in a laboratory and getting them to reproduce of a form of natural selection?

f Think of an argument against selling left-hand spiral pond snails made by CRISPR-Cas in pet shops.

5

Mirrored organs in humans are called '*situs inversus*'.

a Are people with situs inversus mutants?

b Where is the liver in people with mirrored organs? *left* / *right*

c Having mirrored organs is not a problem for people with situs inversus.
If you wanted to avoid mirrored organs in humans, though, would CRISPR-Cas be a good way? Explain your answer.

7 Transcription

LEARNING OBJECTIVES

5.7.13 You can say how transcription and protein synthesis take place in the cell.
5.7.14 You can explain that genetic variation increases due to spontaneous mutations.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES	
	5.7.13	5.7.14
Remembering		
Understanding	2	
Using	4a, 5	3a
Analysing	4b	1, 3b

Your DNA contains information for how you look and for the functioning of your organs and cells. Each characteristic and process requires one or more genes.

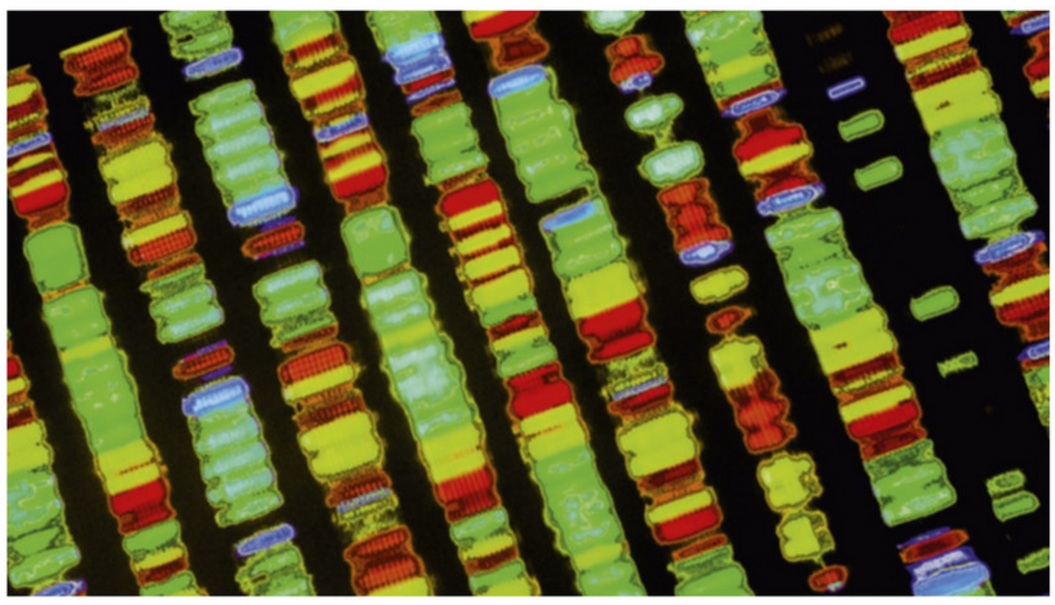
GENE EXPRESSION

Every cell nucleus in your body contains the same genes. But not all genes are active in all cells. Genes in a cell can be switched on and off. Many genes are only switched on under certain conditions. The gene only has an effect then. Activating a gene is called **gene expression**. Whether a gene is on or off can be different for each cell and depends on the function of the cell. For example, the genes used to create hair are switched off in the liver. In the hair follicle cells on your scalp, though, those genes are switched on. When a gene is on, it can be fully or partly enabled.

The order of successive bases in the DNA is called the **DNA sequence** (see figure 1). When a gene is turned on, the DNA information for that gene in the cell is read and processed. The DNA sequence of a gene contains information for producing a specific protein. Proteins largely control the colour, shape and function of your body. Genes contain information for both creating proteins and controlling processes in the cell.

For example, one gene contains the code for producing melanin (a pigment). When this gene is switched on in a cell of the iris, the code for producing melanin is read and melanin is produced. Brown eyes have a lot of melanin, blue eyes very little and green eyes are in between. The amount of melanin is part of the phenotype.

fig. 1 A DNA sequence, using four colours for the four bases.



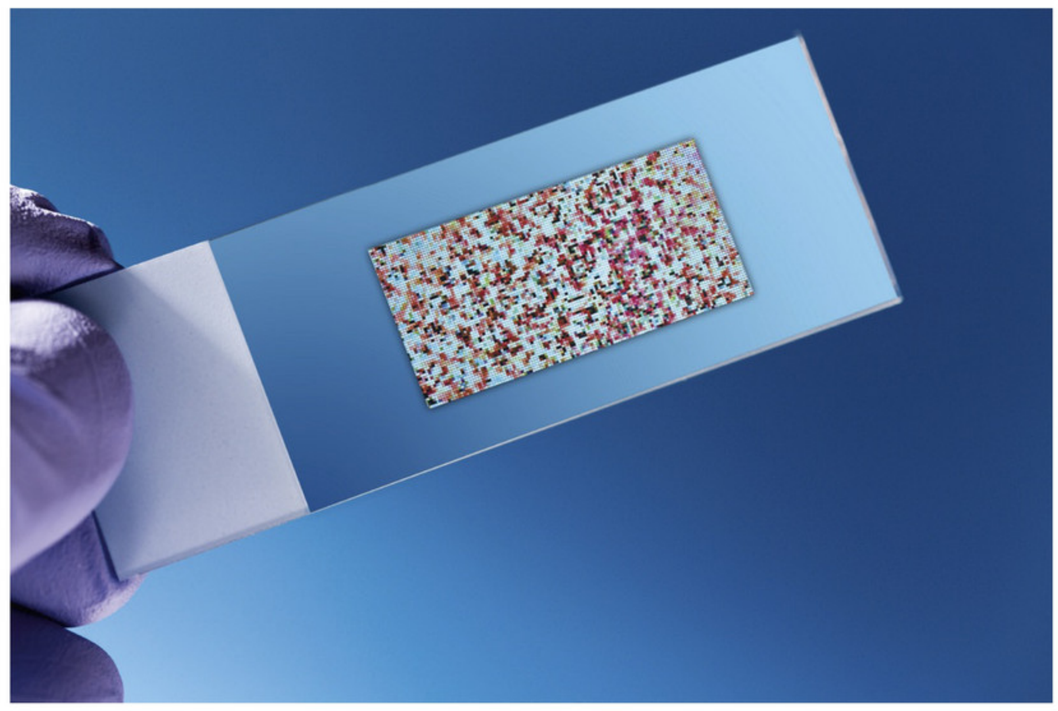
PROTEIN SYNTHESIS

The DNA sequence is a 'recipe' that a cell can use to produce a protein. In gene expression, the DNA sequence is read and copied. The copied piece of DNA is called **RNA**. Making RNA is called **transcription**.
The RNA takes the information for the protein to another part of the cell, called a ribosome, where the code is translated and the correct protein is produced. Producing a protein in a cell is called **protein synthesis** (synthesis means 'making').

Your body can use proteins as fuel, but their function as building material is much more important. Proteins include hormones, enzymes and antibodies, for example. Synthesizing proteins is how your cells make sure that you have enough of these proteins. Switching genes on and off lets cells produce different proteins as the cell needs them.

Figure 2 shows a DNA microarray or DNA chip. This is a technique for measuring gene expression. Each dot represents a gene. The colour shows whether the gene is on or off and how strongly it is on.

fig. 2 DNA microarray or DNA chip.



SPONTANEOUS MUTATION

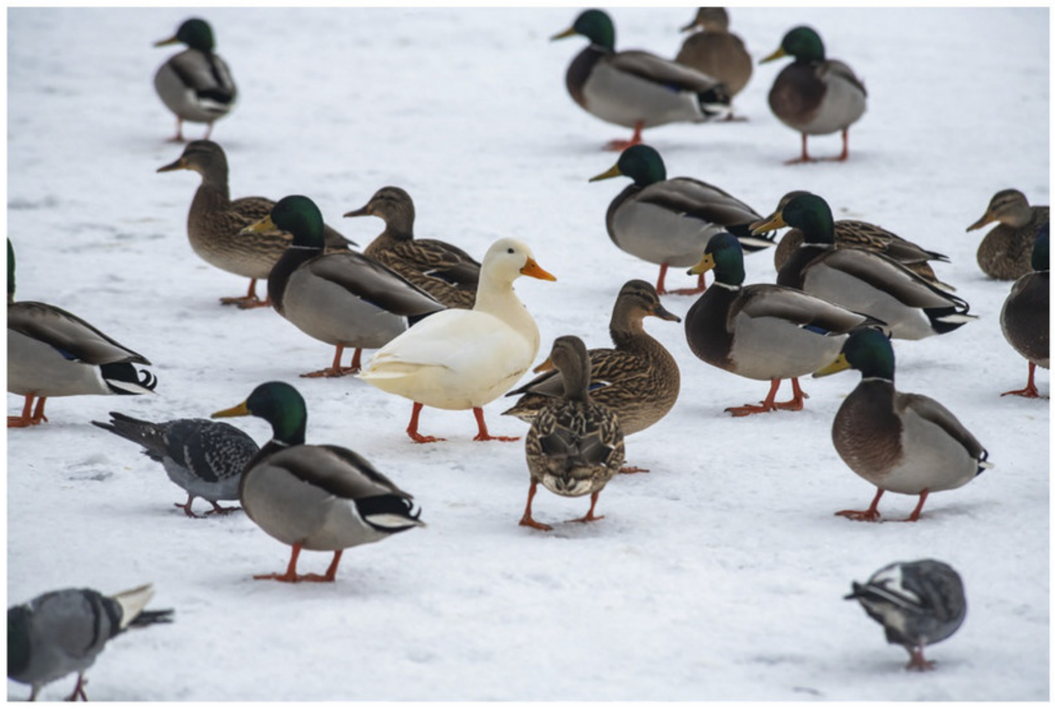
An organism is created by cell division from a fertilized ovum. The chromosomes with the DNA are copied in each cell division. When copying the DNA, errors do occur regularly, resulting in a change in the base sequence. If this happens in a sex cell, the mutation can be passed on to the offspring at fertilization. If this happens at an early stage of an embryo's development, the mutation can also occur in all cells of the body. Half the sex cells of the offspring also contain this mutation.

In body cells, chromosomes occur in pairs. If an allele is mutated on one chromosome, the allele on the other chromosome can take over the function. For example, if one gene for eye colour is broken due to a mutation, there is no problem. However, if the same genes are broken on both chromosomes, the organism can be an albino (see figure 3). The cells cannot produce melanin, because they do not have the correct 'recipe' (DNA sequence).

fig. 3 The eye of someone with albinism.

Many mutations result in deviations in the structure or function of an organism. However, **spontaneous mutations** and **spontaneous hereditary mutations** also increase the genetic variation in the offspring. This can be beneficial to the survival of a population of organisms. If the conditions change, an organism with a mutation may be better adapted than its peers. This mutation might lead to an extra-long neck, such as in a giraffe, or to white feathers in an organism in an area with lots of snow.

fig. 4 A white duck among others of the same species.



EXERCISES

1 The eyes of an albino appear red.
Explain why.

2 **a** The production of proteins takes place in stages.
Put the stages in the right sequence.

..... reading the DNA sequence

..... protein synthesis

..... transcription

b
- Reading the DNA sequence is done in the *nucleus* / *ribosomes*.
- Proteins are synthesised in the *nucleus* / *ribosomes*.
- Transcription is done in the *nucleus* / *ribosomes*.

3 According to the biologist Armand Leroi, every human embryo has about 100 new mutations. However, an embryo also inherits the mutations of its parents, grandparents and distant ancestors. An embryo therefore has an average of 300 mutations that could be harmful to some extent (causing abnormalities or diseases). But not everyone is the same. Some people may only have 250 and a very small number have up to 340.

a Explain how natural selection makes sure that people do not slowly get more and more harmful mutations.

b Explain how our modern society influences natural selection.

4 An allele always starts with the starting code TAC. The end of an allele is indicated by an end code, which is ATT. Between two alleles there is usually a series of DNA building blocks.
Two DNA sequences (P and Q) are shown here. Only the upper row of letters (the code) is read, from left to right, to make a protein.

DNA sequence P

C	**C**	**T**	**T**	**C**	**G**	**C**	**A**	**T**	**T**	**C**	**G**	**T**	**T**	**T**	**C**	**C**	**T**	**A**	**C**	**A**	**A**	**G**	**G**	**C**
G	G	A	A	G	C	G	T	A	A	G	C	A	A	A	G	G	A	T	G	T	T	C	C	G

DNA sequence Q

T	**A**	**C**	**C**	**C**	**G**	**A**	**T**	**C**	**A**	**G**	**G**	**C**	**G**	**T**	**G**	**C**	**G**	**T**	**C**	**G**	**T**	**T**	**T**	**C**
A	T	G	G	G	C	T	A	G	T	C	C	G	C	A	C	G	C	A	G	C	A	A	A	G

a Does either of these DNA sequences contain a complete allele? If so, which? Explain your answer.
b Does either of these DNA sequences contain pieces of two alleles? If so, which? Explain your answer.

5 Your hair colour is a characteristic that can change. Many people have blond hair as children but a different hair colour as adults. Some babies with dark hair get lighter hair later.
Explain why the hair colour may change.

Go to the *Flash cards*.

8 Dominant and recessive

LEARNING OBJECTIVE

5.8.15 You can describe what homozygous, heterozygous, dominant and recessive mean.

► Practical activity 3

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES		
	5.7.15	5.3.6*	5.7.13*
Remembering			
Understanding	1a, 2a, 3a		2b
Using	1b, 3bcd	3d	2cd
Analysing	1c	1c	

* You can find this learning objective in another Basics section.

You have learned that an allele pair can contain two identical or two different alleles for a certain hereditary characteristic. In a non-identical allele pair, the stronger allele is reflected in the phenotype.

HOMOZYGOUS AND HETEROZYGOUS

Figure 1 shows you that people can have an identical allele pair for hair type, for instance two alleles for straight hair or alleles for curly hair. An organism with an identical allele pair for a given hereditary characteristic is said to be **homozygous** for this characteristic (*homo* = the same).

A person may have a non-identical allele pair for a certain characteristic, Example: one allele for curly hair and one for straight hair. An organism with a non-identical allele pair for a given characteristic is said to be **heterozygous** for this characteristic (*hetero* = different). Humans can therefore be homozygous or heterozygous for the hair type.

fig. 1 Homozygous and heterozygous.

1 homozygous for straight hair
2 homozygous for curly hair
3 heterozygous for hair type

Key:
allele for straight hair
allele for curly hair

DOMINANT AND RECESSIVE

People who are heterozygous for their hair type have the allele for straight hair as well as the allele for curly hair. These people turn out to have curly hair. Only one of the two alleles is reflected in the phenotype. We call this the **dominant allele**. The other is called the **recessive allele**. This allele is not expressed in the phenotype if there is a dominant allele in the other chromosome of the pair of chromosomes. The dominant allele is 'stronger' than the recessive allele, as it were.

The hide colour of cattle can be brown – though usually called 'red' – or black (see figure 2). If it is known that the black bull is heterozygous for hide colour, then you know that the allele for black hide is dominant. The bull has an allele for red and an allele for black hide, but the phenotype is a black hide. Only the allele for a black hide is reflected in the phenotype, so the allele for black hide is dominant.

This also tells you that the brown bull is homozygous for the hide colour because if that bull had one dominant black allele, its hide would have been black. Knowing that the brown hide colour is recessive would be enough to tell you that the brown bull is homozygous for hide colour. You do not know this for the black bull: it could be homozygous or heterozygous for the hide colour.

fig. 2 Cattle.

1 red hide – homozygous

2 black hide – homozygous or heterozygous?

GENE SYMBOLS

Alleles are indicated by letters. One letter is used for a single hereditary characteristic. A dominant allele is shown by a capital letter and a recessive allele by a lowercase letter. Example: a person who is homozygous for curly hair (dominant) is indicated as AA, a person who is homozygous for straight hair (recessive) as aa and a person who is heterozygous for hair type as Aa. You can also use a different letter, BB, bb and Bb for example. It is best to always use letters whose uppercase and lowercase forms are clearly different in shape (for instance R and r rather than P and p).

EXERCISES

1 Some people have to sneeze when they suddenly look into bright light, like the boy in figure 3. About a quarter of all people have this. The precise way this reflex works is still unknown. The boy in the picture has the genotype Dd for the sneezing reflex.

a Is the boy heterozygous or homozygous for the sneezing reflex? *heterozygous / homozygous*

b Which allele is dominant?
the allele for sneezing in bright light / the other allele

c Do the parents of the boy also have the sneezing reflex when they look into bright light?

- ○ A Yes, both parents do.
- ○ B At least one of the parents does.
- ○ C No, neither parent does.

fig. 3 A boy sneezing when looking into bright light.

2 Read the text 'Who's who?' in figure 4.

a Which of the four teenagers is heterozygous for hair colour?
Mary-Lou / Marilyn / Philip / Pat

b Which of the four teenagers is homozygous for skin without freckles?
Mary-Lou / Marilyn / Philip / Pat

c Use Philip's phenotype to determine whether the alleles for dark hair and freckled skin are dominant or recessive.
- The allele for dark hair is *dominant / recessive*.
- The allele for freckled skin is *dominant / recessive*.

d So which name matches which photo?

Photo 2	*Mary-Lou / Marilyn / Pat*
Photo 3	*Mary-Lou / Marilyn / Pat*
Photo 4	*Mary-Lou / Marilyn / Pat*

fig. 4

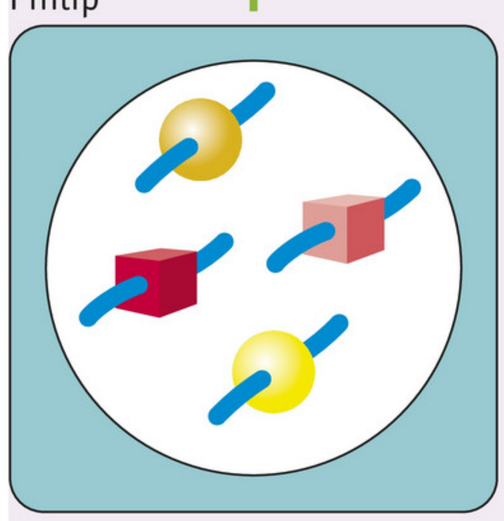
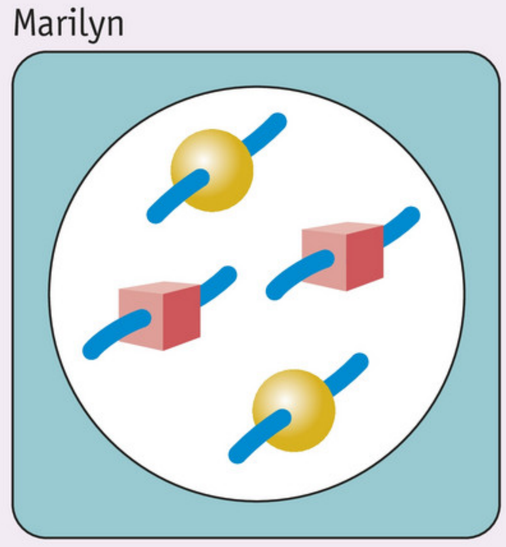
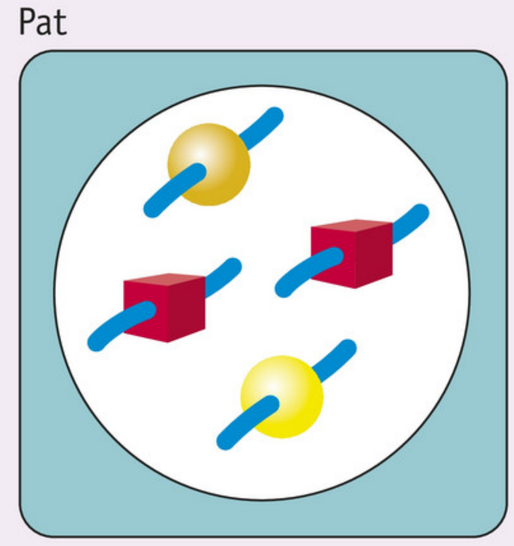
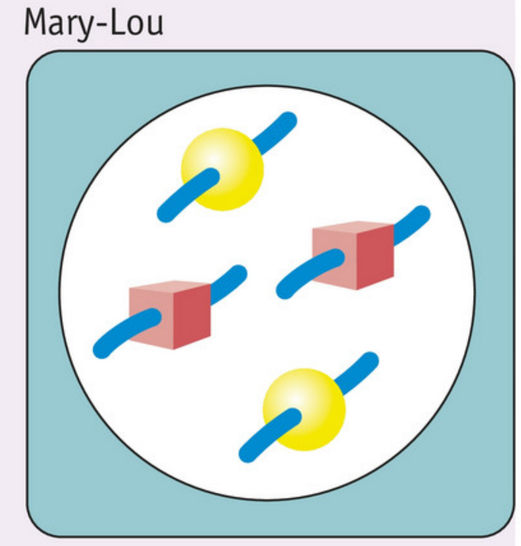
Who's who?
The photos show you the phenotypes of four people, with variation in skin type and hair colour. The skin type is either freckled or not, and the hair colour is either dark or blonde (see photos 1 and 3). Beneath the photos, there are schematic drawings of the body cells of these people. Both the genotype and the phenotype for these two characteristics are shown for Philip, but only the genotypes are known for Mary-Lou, Marilyn and Pat. Who is who in photos 2, 3 and 4?

1
Philip

2 ?
Marilyn

3 ?
Pat

4 ?
Mary-Lou

allele for blonde hair

allele for dark hair

allele for non-freckled skin

allele for freckled skin

3 One of the first genetic experiments was performed by an Austrian monk called Gregor Mendel. He cross-bred sweet pea plants with each other. He grew wrinkled and round peas (see figure 5). The shape has to do with the production of carbohydrates. Wrinkled peas contain more sugar and less starch than round peas, so they dry out as they ripen. Wrinkled peas are sweeter than round peas.

a In the case of peas, the allele for a wrinkled pea (r) is recessive to the allele for a round pea (R).
Could pea 1 be homozygous for the shape? Could it be heterozygous?

b What is the genotype of pea 1? .....

c Could pea 2 be homozygous for the shape? Could it be heterozygous?

d The pollen grain that pea 2 from originated contained the allele r.

Which allele did the ovum contain? .....

fig. 5 A wrinkled pea and a round pea.

Go to the *Flash cards*.

Learning how to do research

1 PRESENTING YOUR RESEARCH VERBALLY

► Basics 6 | ► Learning objective 5.0.16

Researchers share their research results so that they can progress further together. They can do this with a written or verbal presentation. In a verbal presentation, you tell others about your research and your results. You often do this using a slide show, for example in PowerPoint. When using a slide show, follow the sequence shown in figure 1. You don't write everything down on the slides; you use keywords, images, drawings and diagrams. This lets the slides support what you are saying.

You usually have to present your research within a certain time. You'll need to tell your story in ten or twenty minutes, for instance. That is why you only give the key information about your research in a verbal presentation. This is different from a written presentation because you describe your research as extensively as possible there.

fig. 1

Creating a research presentation

1. State the title of your study on the first slide. Put your name and the names of the people you have been working with under the title.
2. Introduce your research. Say what problem you wanted to investigate. Provide an additional explanation of the subject if necessary. Use one or two slides for this.
3. Then you divide your presentation into sections that match the research steps:
   - Research question
   - Hypothesis (if you have one)
   - What do you need?
   - Work plan
   - Results
   - Conclusion
   - Discussion

   Each step will have a separate slide. If you have a table or chart of your results, make it as large as possible so that your audience can see it well. Each table and chart will have its own slide.
4. If you have used sources, put a literature list on the last slide.

EXERCISE

1 You are going to think up and carry out a literature review and present it verbally. You can choose one of the following topics:

- CRISPR-Cas (or another DNA technique)
- sex chromosomes in birds
- cancer (such as breast cancer, colon cancer or testicular cancer)
- sickle cell anaemia
- Down's syndrome

If you want to choose another topic, ask your teacher.

Do your research as follows:

- Write down the study question and its sub-questions.
- Make a work plan. The work plan contains:
  - what sources you will consult;
  - where you are going to find the sources.
- Get your teacher to check the research question, the sub-questions and the work plan.
  Carry out the study according to the work plan.
- Write down the results for each sub-question.
- Write down a conclusion that answers the research question.
- Write a discussion.
- Create a slide show of your study. Use as few whole sentences as possible and as many keywords, images, drawings and diagrams as possible.
- Prepare what you want to say for each slide. If necessary, make a crib sheet with keywords.
- Present your research to the class.

Practical activities

1 NATURAL SELECTION

► Basics 4 | ► Learning objective 5.4.9

30-35 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you mimic natural selection within a group of organisms. To do this, use the events in figure 1. You keep a record in the table of how the group composition changes.

fig. 1

Events in each generation

Event 1
The red beads have a characteristic that means they are easily seen by predators. The chance of them living long enough to have offspring is 60%. The survival rate of the other colours is 80%.

Event 2
The group finds some dense woodland to live in. The green beads have a characteristic that makes them even less noticeable in the woods. This increases their chance of survival by 10%. The chance of survival for the other colours remains the same.

Event 3
Climate change is making the summers hotter and hotter. This reduces the chance of survival for almost all colours by 10%. The yellow beads have a characteristic that makes them more resistant to the heat. In this colour, the chance of survival is not reduced.

Event 4
There is a forest fire in the population's habitat. 50% do not survive this fire.

WHAT DO YOU NEED?

- ☐ 30 blue beads
- ☐ 30 yellow beads
- ☐ 30 green beads
- ☐ 30 red beads
- ☐ a calculator

WORKING METHOD

- Put five blue, five yellow, five green and five red beads together. This is the first generation of the group. The composition of this generation has already been entered in the table.

Event 1

- Read Event 1 in figure 1. 60% of the red beads remain alive after this event.
- Calculate the number of red beads that will stay alive in your group.
- Remove the other red beads.
- Do the same for the other three colours. Note: the survival rate for the other colours is 80%.

The group of beads that remains is the population after Event 1. These beads have offspring: there is one offspring for each coloured bead, so the group doubles in size.

- Double the number of beads of each colour in the group. The beads that are added are the offspring. The population now consists of two generations.
- Write down the composition of the population with two generations.

Event 2

- Read Event 2 in figure 1. The chance of survival of one of the colours has changed.
- For each colour, calculate the number of beads that remain alive after Event 2. Round each outcome off to a whole number if necessary.
- For each colour, remove the beads that don't survive.

The beads that are still alive now have offspring: one offspring for each bead. You don't have to take into account that there are two generations.

- Add the offspring to the population. The population now consists of three generations.
- Write down the composition of the population in the table.

Event 3

- Read Event 3 in figure 1.
- For each colour, calculate the number of beads that survive. Round of to a whole number if necessary and remove the other beads.
- In the table, add the offspring and record the composition of the population with four generations.

Event 4

- Read Event 4 in figure 1. Now the chance of survival has been given for the whole group rather than for each colour. The chance of survival for a bead does not therefore depend on its colour.
- Remove half the beads from the group randomly (for example with your eyes closed).
- In the table, add the offspring and record the composition of the population with five generations.

Number of generations	Number of blue beads	Number of yellow beads	Number of green beads	Number of red beads
1	5	5	5	5
2				
3				
4				
5				

EXERCISE

1 Explain why Event 4 is not natural selection.

2 COMPARING THE SKULLS OF RODENTS

► Basics 5 | ► Learning objective 5.5.11

20-30 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you are going to compare the skulls of three rodents.

WHAT DO YOU NEED?

- ☐ a squirrel skull
- ☐ a rabbit skull
- ☐ a field mouse skull

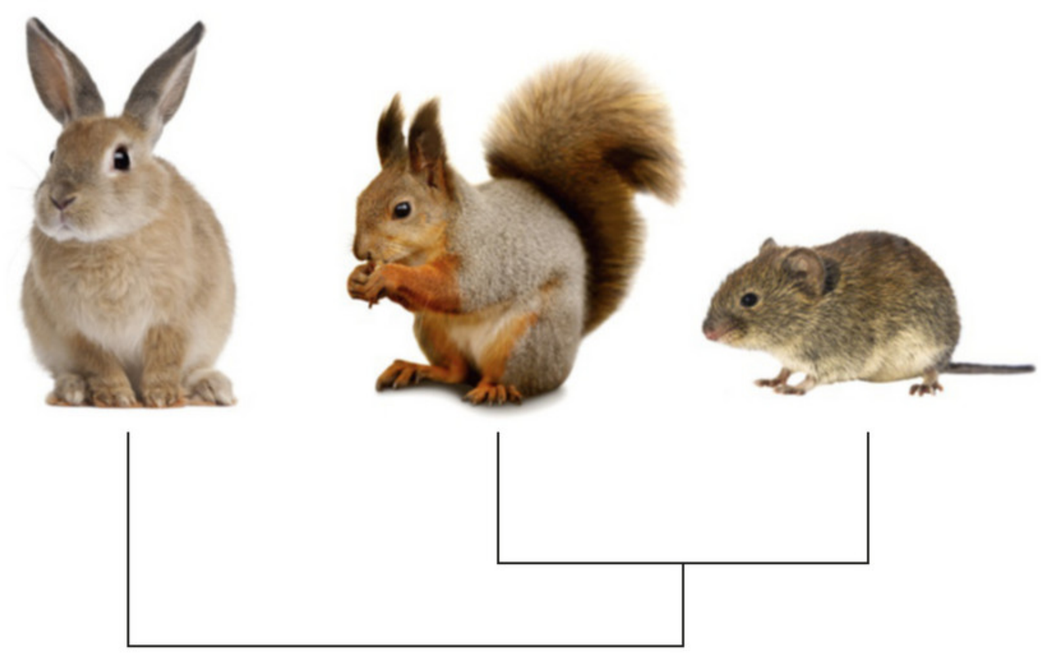
WORKING METHOD

- Study the three different skulls.
- Look at the similarities and differences you can see.

EXERCISE

1
a What similarities did you find in all three skulls? Write down at least two.
b What differences did you find between the skulls? Write down at least two.
c Have a look at the family tree in figure 2.
Which animal is more closely related to the squirrel? *rabbit* / *field mouse*
d Does the kinship correspond to the similarities and differences you found? *yes* / *no*

fig. 2 Family tree diagram.



3 PREDICTING THE PHENOTYPE

► Extra 8 | ► Learning objective 5.8.15

25-35 minutes

WHAT ARE YOU GOING TO DO?

Your teacher has six insects made from marshmallows and other materials. Each insect has a different phenotype. In this practical activity, you determine the genotype of a descendant of two insects and 'translate' it into a phenotype.

WHAT DO YOU NEED?

- ☐ marshmallows
- ☐ toothpicks
- ☐ paper clips
- ☐ yellow, red and orange beads

WORKING METHOD

- Select two insects from the group of six. One insect is a male (genotype XY) and the other a female (genotype XX). You can decide for yourself which insect is the male and which is the female.
- Record the genotypes of the two insects. Use table 1 for this. Assume your insects are homozygous.
- Record the genotypes of your two insects' offspring. Use table 1 for this.
- Create the offspring with the correct phenotypes. Use the marshmallows, toothpicks, paper clips and beads.

Table 1 Genotypes and phenotypes.

Genotype	Phenotype
TT or Tt	two pairs of wings
tt	one pair of wings
AA or Aa	long antennae
aa	short antennae
GG or Gg	long legs
gg	short legs
BB	red eyes
Bb	orange eyes
bb	yellow eyes

EXERCISE

1 **a** For which characteristics is the descendant heterozygous and for which is it homozygous?
Write down the characteristics of the offspring in the table. Use the terms *antennae – eyes – legs – wings*.

	Characteristics of the offspring
Homozygous dominant	
Homozygous recessive	
Heterozygous	

b Can you predict the sex of the offspring? If so, what is the sex? If not, why not?

Summary

BASICS 1

GENOTYPE AND PHENOTYPE

1 You can describe what the genotype and phenotype are.

- Chromosomes are thin 'threads' found in the nucleus of each cell.
  - They consist largely of the substance DNA.
  - DNA carries the information for inherited characteristics.
  - Each nucleus contains the complete information for all inherited characteristics of an organism.
  - Gene: the pieces of DNA that together contain the information for a hereditary characteristic.
- Genotype: the information for the hereditary characteristics in an organism.
  - All genes in a nucleus taken together form the genotype.
  - The genotype is determined at the moment of fertilization.
- Phenotype: the characteristics of an organism, including its appearance.
  - The phenotype is created by the genotype and environmental influences (lifestyle and surroundings).

2 You can explain that cells only use the hereditary information that they need.

- A cell only uses the genes that it needs.
  - In this cell, the other genes are not active.
  - This is related to the function of a cell. For example, in liver cells the genes for bile production are switched on. These genes are turned off in head skin cells.
  - A gene can be activated fully or partially.

BASICS 2

CHROMOSOMES

3 You can explain how each of the parents supplies 50% of the chromosomes.

- The chromosomes in body cells occur in pairs.
  - The two chromosomes of a pair consist of the same genes.
  - In humans, the nucleus of each body cell contains 23 pairs of chromosomes.
  - One chromosome in each pair comes from the mother and one from the father.
- Gene variant: the information on one of the genes of a gene pair.
  - In body cells, the two gene variants of a gene contain information for the same genetic characteristic.
  - This information can be identical or non-identical. For example, the gene for hair type may contain information for straight hair and/or for curly hair.
- However, the chromosomes do not occur in pairs in reproductive cells; instead, there is just a single copy.
  - In humans the nucleus of each sex cell contains 23 chromosomes.
  - Which of the two chromosomes ends up in a sex cell depends on random chance.

4 You can say how the sex of humans is determined by sex chromosomes.

- Sex chromosomes: the 23rd chromosome pair:
  - female: two X chromosomes (XX)
  - male: one X and one Y chromosome (XY)
  - intersex: for example a girl with XY or a boy with XX

5 You can explain how sexual reproduction causes variation in genotypes.

- Sex cells are formed with just one chromosome from each chromosome pair.
  - Sex cells are created by a special form of cell division called meiosis.
  - In meiosis, the chromosomes are divided between the daughter cells (sex cells). This takes place randomly and makes sure that many different genotypes occur in sex cells.
- In sexual reproduction, the nucleus of a sperm cell and the nucleus of an ovum fuse.
  - Which genotype these sex cells will have depends on random chance.
  - Sexual reproduction produces variation in genotypes.

BASICS 3

GENES AND ALLELES

6 You can describe what genes and alleles are.

- DNA is made up of base pairs (A–T and C–G).
  - DNA sequence of a gene: the specific sequence of bases.
  - This creates a code with information.
  - The DNA contains information for producing substances and for cellular processes.
- Genes contain the information for creating proteins.
  - The colour, shape and functioning of your body is mostly directly controlled by proteins.
  - The base pairs of a gene can be side by side, but they are usually split across one or more chromosomes.
  - All characteristics require multiple genes.
  - Base pairs (pieces of DNA) can be part of several genes.
- Allele: gene variant, the information in a gene on one chromosome.
  - The two alleles of a gene make an allele pair.

7 You can describe what a mutation is.

- Mutation: a sudden change in the genotype.
  - Mutant: an organism with a visible phenotype mutation.
- When there is a mutation in a body cell, this usually has no consequences.
  - The genotype of the other body cells remains unchanged.
- But if a mutation occurs in a sex cell, this may have a major effect.
  - If this sex cell is involved in the fertilization, every body cell of the offspring contains the mutated gene.
- Mutations occur more often after exposure to mutagenic influences:
  - radiation (such as radioactivity, X-rays or the UV radiation in sunlight)
  - certain chemical substances (for instance in tobacco smoke or asbestos)

8 You can describe what cancer is.

- Occurrence of cancer: a cell starts to divide out of control somewhere in the body.
  - Cause: mutations in genes involved in the regulation of cell division.
  - A malignant tumour develops and the structure of the tissue is disrupted.
- Metastasis: tumour cells enter the blood or the lymph.
  - These cells cause new tumours in other organs.

BASICS 4

THE THEORY OF EVOLUTION

9 You can describe the theory of evolution.

- Evolution: the development of life on Earth in which species emerge, change and/or disappear.
  - The theory of evolution is based on a timescale of millions of years, variation in genotypes, natural selection and the creation of new species.
- In nature, new genotypes (and phenotypes) are constantly emerging.
  - Variation in genotypes is caused by sexual reproduction and mutations.
- Natural selection:
  - Individuals that are better suited to their environment will have a greater chance of survival.
  - Organisms with a favourable genotype are likely to have many surviving offspring that can reproduce.
  - Species change when natural selection results in the survival of organisms with a new, altered feature while organisms with the original feature become extinct.
- Isolation causes new species:
  - A group of organisms of a single species becomes isolated (separated) from the rest of their species.
  - Both groups continue to develop in different environments over a long period.
  - Over time, so many differences have developed that organisms of the two groups cannot reproduce with each other. There are now two different species.

BASICS 5

THE HISTORY OF LIFE ON EARTH

10 You can explain how fossils are created.

- Fossils: remains of organisms that have turned to rock (mineralized, petrified) or prints of organisms in rocks.
  - Fossils are created when a dead organism is cut off from oxygen by a layer of sand or clay (sediment). This stops the remains from decaying.
  - Hard parts of organisms fossilize more easily than soft parts.
  - The fossil record tells us that in the course of evolution, species emerge, change and/or disappear.

11 You can explain that species are related if they have a common ancestor.

- A geological timeline shows the time since the Earth came into being.
- The kinship between species is closer if they have a more recent common ancestor.
  - The longer ago that two species had a common ancestor, the less closely related they are.
- Similarities in DNA, proteins and phenotype:
  - The more similar the DNA, proteins and phenotype of two species are, the more likely it is that these species have a recent common ancestor.
- Similarities in phenotypes:
  - Organs with different functions can have a lot of similarities in their structure. Example: the arm of a human, the wing of an eagle and the front flipper of a walrus.

- Rudimentary or vestigial organs: organs that have only retained part of their function and do not develop (or only develop very little). Examples: the tail vertebrae and the wisdom teeth in humans, legs in a snake. These organs may still be fully developed and used in related species.
- You can read off the following information from a branching tree of organisms:
  - what other groups a group of organisms developed from;
  - which groups are closely related to each other and which groups are not closely related.

BASICS 6 DNA TECHNIQUES

12 You can describe various DNA techniques in biotechnology.

- Biotechnology: the collective name for techniques that use organisms to make products for humans.
- Genetic modification: when humans change the genetic characteristics of other species of organisms.
  - A genetically modified organism (GMO) is said to be 'transgenic'.
- Recombinant DNA techniques: new genetic information is inserted in the DNA of an organism (such as DNA from another species of organism).
  - The altered organisms can produce foods, medicines, hormones or enzymes for humans. For example, bacteria can produce the hormone insulin after the human gene for producing insulin has been introduced into them.
- CRISPR-Cas: gene editing using the bacterial defence mechanism against viruses.
  - A bacterium that survives a virus attack stores the virus DNA.
  - The Cas enzyme checks the bacterium for the presence of viral DNA.
  - If such DNA is found, the enzyme cuts it into pieces.
  - Gene editing with CRISPR-Cas: Cas finds the piece of DNA that needs to be changed and cuts it out. The ends are glued together or a new piece of DNA is built in.
- Discussion: there are supporters and opponents of genetic modification.
- Genomics: studying the entire DNA of an organism with all the genes that it contains.
- DNA tests are cheap, fast and accurate.
  - Applications such as fighting crime, detecting meat fraud, detecting hereditary diseases, kinship testing.
- eDNA: environmental DNA.
  - All organisms leave DNA traces in their environments.
- Synthetic biology: the artificial recreation of biological material. Examples: artificial DNA, applications in the future may include cleaning up pollution, biofuel production, data storage.

EXTRA 7

TRANSCRIPTION

13 You can describe how transcription and protein synthesis take place in the cell.

- Genes contain information for producing proteins and controlling cellular processes.
  - Proteins are largely responsible for determining the colour, shape and functioning of your body.
- Gene expression: a gene is expressed in the phenotype.
  - Genes can be switched on or off, fully or in part.
  - The DNA sequence of a gene contains the information for producing a specific protein.
- Protein synthesis: producing a protein in the cell.
  - Transcription: the DNA sequence of a gene is read and copied.
  - The copied piece of DNA is called RNA.
  - In another part of the cell, a protein is produced using the information in the RNA.

14 You can explain how genetic variation increases due to spontaneous mutations.

- Errors occur regularly when DNA is copied.
  - If this happens in a sex cell involved in fertilization, or in the embryo shortly after fertilization, the mutation will be present in all the cells of the offspring.
  - Mutations create variation in genotypes and phenotypes.
  - Spontaneous hereditary mutations can affect the survival of an organism positively or negatively.

EXTRA 8

DOMINANT AND RECESSIVE

15 You can describe what homozygous, heterozygous, dominant and recessive mean.

- Homozygous: the allele pair for a characteristic consists of two identical alleles.
- Heterozygous: the allele pair for a characteristic consists of two different alleles.
- Dominant allele: an allele that is always reflected in the phenotype.
  - A dominant allele is indicated by a capital letter.
  - Organisms where a dominant allele is expressed in the phenotype may be homozygous or heterozygous for that characteristic.
- Recessive allele: an allele that only appears in the phenotype if there is no dominant allele present.
  - A recessive allele is indicated by a lowercase letter.
  - Organisms where a recessive allele is expressed in the phenotype are homozygous for that characteristic.

RESEARCH

LEARNING HOW TO DO RESEARCH & PRACTICAL ACTIVITIES

16 You can give a verbal presentation of an investigation.

Go to the *Flash cards* and the *Diagnostic test*.

6 Ecology and sustainability

Organisms live in a relationship with their environment. They need nutrients and many organisms themselves serve as food for other organisms. Ultimately all organisms die. The substances that they are made from then get used again.

BASICS

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7 The energy flow in an ecosystem 239
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TO FINISH

Summary 264
Diagnostic test

1 Organisms and their environment

LEARNING OBJECTIVES

6.1.1 You can classify the influences on organisms into biotic and abiotic factors.
6.1.2 You can describe the levels of ecology.
6.1.3 You can indicate the various feeding relationships in an ecosystem.

- Learning how to do research 1
- Practical activity 1

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES		
	6.1.1	6.1.2	6.1.3
Remembering	1abe	2cd	3ab, 4ab
Understanding	1cd, 5, 6a	2ab, 5, 11b	3cde, 4c, 5
Using	6b, 11a	7, 11c	8, 9, 10, 11de
Analysing	6c		

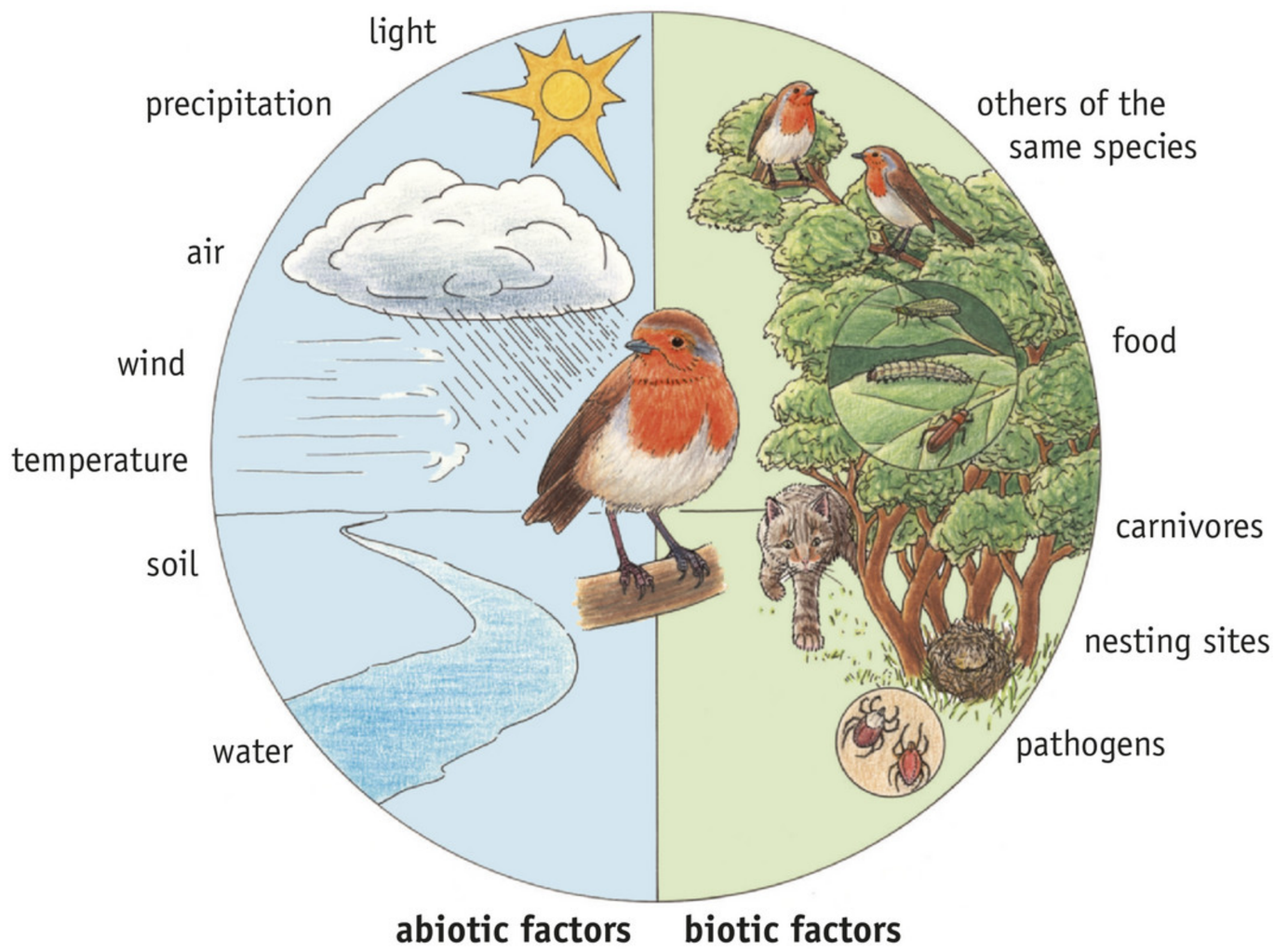
Every organism is dependent on its surroundings. That environment consists not only of other organisms but also of non-living factors such as light, water and air. Many organisms live together in groups.

ENVIRONMENT

The **environment** (the surroundings they live in) affects organisms and organisms also affect their environment. For example, plants give off oxygen to the environment and earthworms make tunnels that loosen up and aerate the soil. The part of biology concerning the relationships between organisms and their environments is called **ecology**.

Influences that come from living nature are called **biotic factors**. These influences come from other organisms. Influences that come from the non-living aspects of nature are called **abiotic factors**. Figure 1 shows biotic and abiotic factors that affect a robin.

fig. 1 Biotic and abiotic factors for a robin.



THE LEVELS OF ECOLOGY

Biologists study life at various levels, such as a cell, an organ or an organism. There are also various **levels** in the relationships that ecologists investigate (see figure 2).
You can investigate the relationships between one **individual** (an organism) and its environment, for example the effect of the temperature on the growth of a single elephant.

fig. 2 The levels of biology.

Biosphere: planet
The area on the Earth (water, soil and atmosphere) where life is possible.

Ecosystem: Hoge Veluwe
A specific area in which the biotic and abiotic factors form a unit.

Individual: wild boar
Organism, a single living creature.

Population: wild boars
A group of organisms of the same species that live together in an area.

Community: wild boar, deer, badgers, oak trees, etc.
All the populations in an area.

A **population** is a group of individuals of the same species in a given area, which reproduce together. An example of a relationship between a population and its environment is the influence of the amount of rain on a population of elephants.

Populations of different species live together in a given area. These populations together make up a **community**. The community of a woodland can consist of populations of oak and beech trees, bracken ferns, earthworms, shrews, great tits, foxes and many other species. All the populations in the woodland affect each other. Abiotic factors such as temperature, water and soil type also have a lot of influence on the woodland. All the abiotic factors together in a given area are called the **biotope**.

The community and biotope of a piece of woodland together form an integral whole: the **ecosystem**. An ecosystem is an area in which the biotic and abiotic factors form a unit. Examples of ecosystems are dunelands, woodlands, ponds and meadows. All the ecosystems combined form the **biosphere**. The biosphere is that part of the Earth – in, on and around it – where life is possible.

fig. 3 A pond.

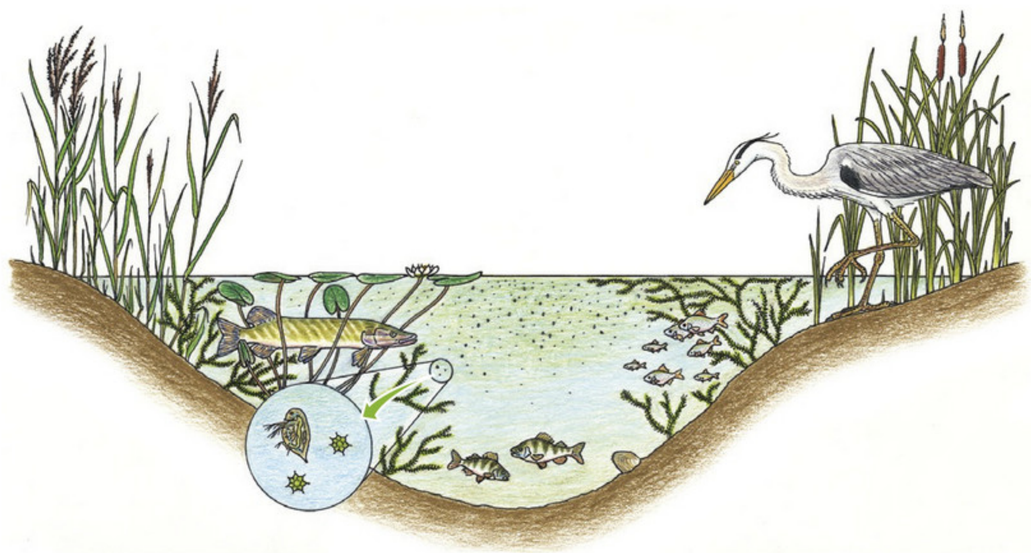


fig. 4 A food chain.

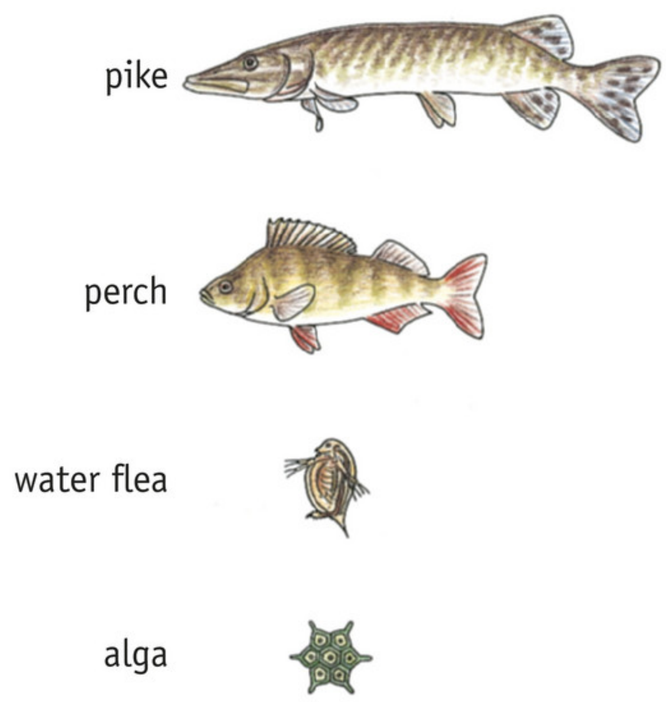
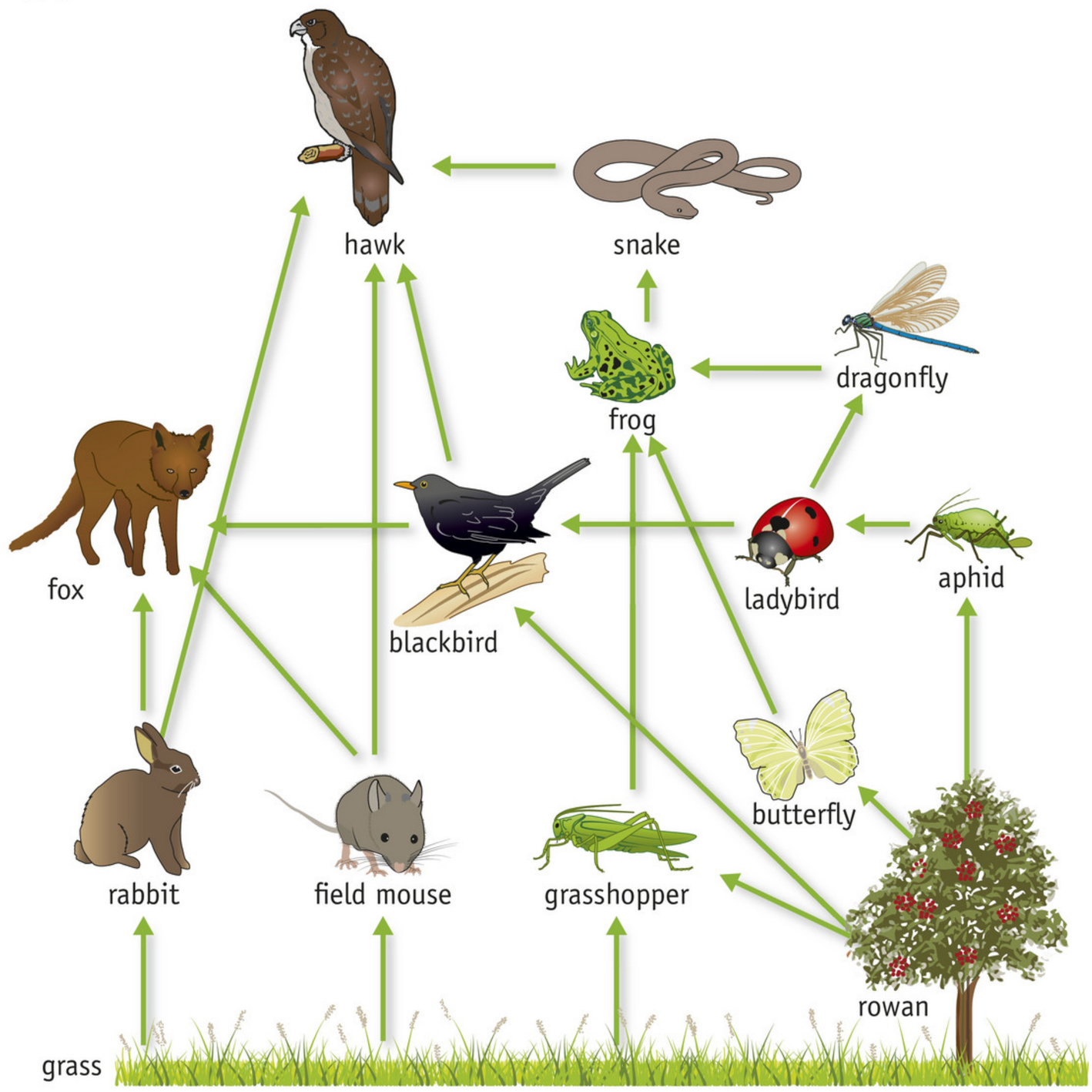


fig. 5 A food web.



FOOD CHAIN

Figure 3 shows a lake with several organisms. The magnified image shows a water flea. Water fleas are herbivores (plant eaters). They eat algae. It also shows perches. Perch eat water fleas. They are carnivores (meat eaters). It also shows a pike. Pikes eat – among other prey – perch.

Algae, water fleas, perch and pike make up a **food chain** (see figure 4). A food chain is a series of organisms in which each organism is the food source for the next. Each food source is called a **link** in the food chain. The first link in figure 4 is a plant species. Almost all food chains start with a plant species. From there, an arrow points to the second link: a water flea (a herbivore). From the herbivore, an arrow points to the third link: a perch (a carnivore). The second, third and subsequent links can also be omnivores.

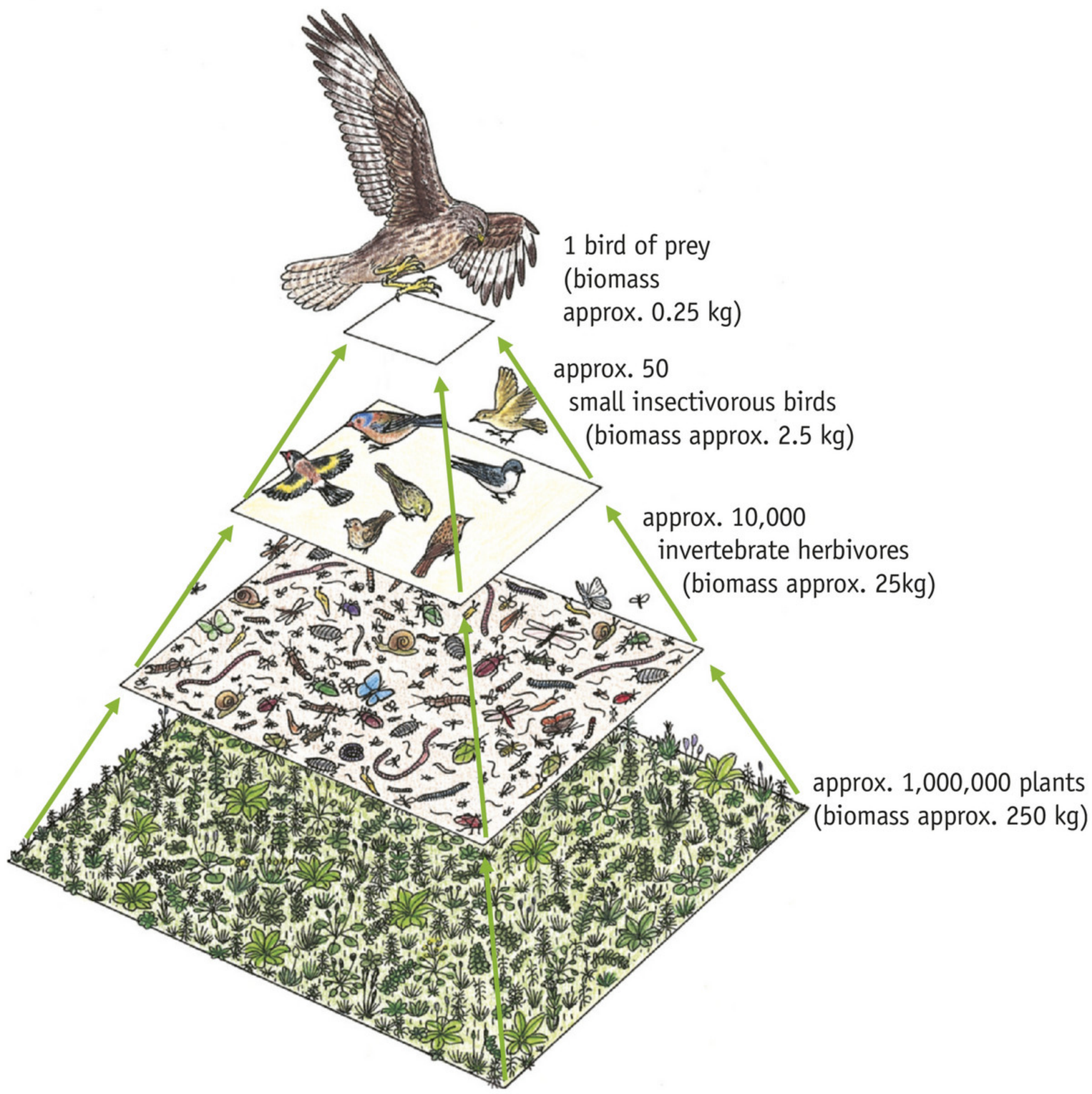
In reality, an ecosystem never contains just a single food chain. Each species can serve as food for many other species. In an ecosystem, the food chains are interrelated and form a network. All the feeding relationships in an ecosystem are called a **food web** (or **food network**). Figure 5 is a drawing of a food web. As well as herbivores and carnivores, a food web also contains omnivores (that eat both kinds of food). A food web consists of living organisms.

BIOMASS

Every organism is made up of many different substances. Some of these are high-energy substances such as carbohydrates, proteins and fats. The total amount of all the high-energy substances in an organism is referred to as that organism's **biomass**.

You can see the amount of biomass contained in each level of a food chain. You have to add up the biomass of all the organisms in a link. Figure 6 shows the biomass for each link. You can see that the total biomass of the plants in the first link is a lot bigger than the biomass of the herbivores above it. The biomass at each subsequent level of a food chain decreases.

fig. 6 Pyramid of biomass.



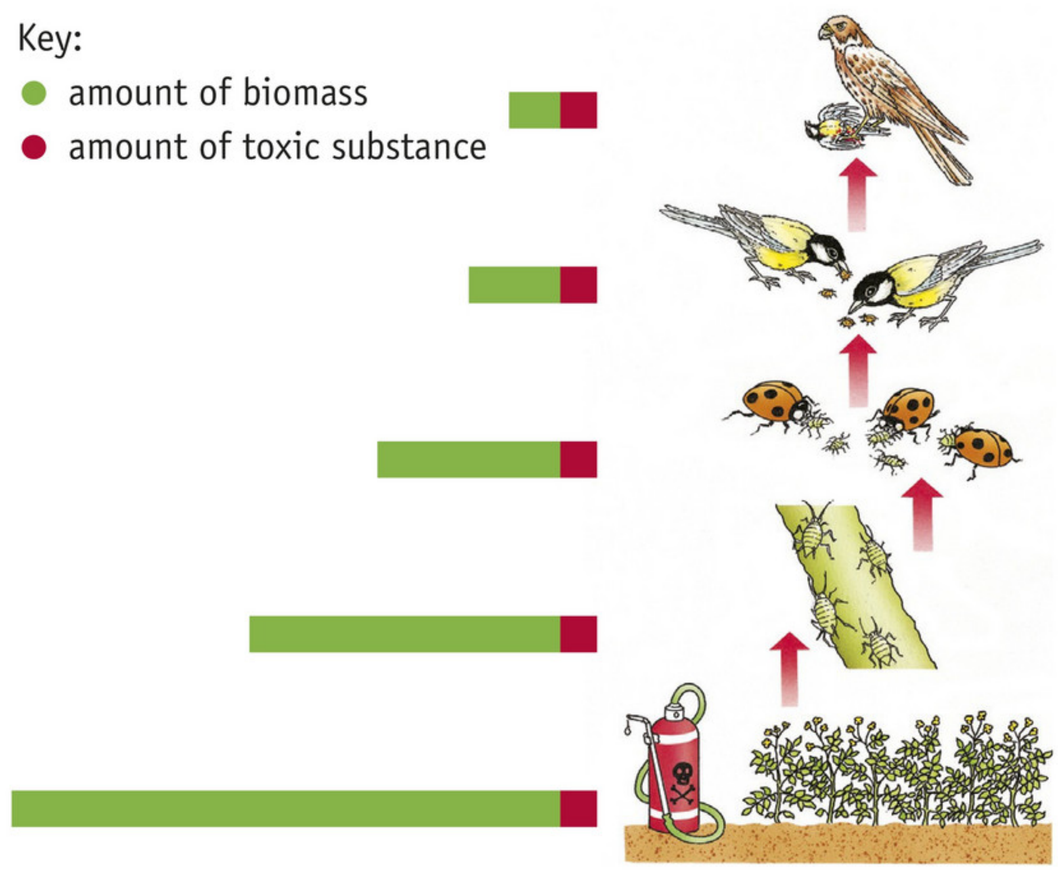
ACCUMULATION

Plants take up substances from their environment, for example as minerals and carbon dioxide. These substances are useful to the plant. But plants also take up substances they do not need, like heavy metals. That is a collective term for metals such as cadmium, mercury, lead, arsenic and tin. Heavy metals are **toxic** (poisonous, harmful to organisms). They end up in the environment from industry, car exhaust gases and the combustion of coal and waste.

A plant cannot use heavy metals and also cannot get rid of them. As a result, these substances remain in the plant cells and get into the food chain. When the plant gets eaten by an animal, the substances get transferred to the animal. In animals, heavy metals get stored in fatty tissue. They can then get passed on to the next level in the food chain. This is how toxic substances build up in the animals at the end of the chain (see figure 7). This is called **accumulation**. The same quantity of heavy metals ends up in smaller and smaller amounts of biomass. This is the reason why animals at the end of food chains are at greater risk of dying from heavy metal poisoning.

Not only heavy metals build up in the food chain. Chemical products from agriculture are also transferred in a food chain. There are all sorts of government measures that mean less and less heavy metals and toxic substances are getting into the environment.

fig. 7 Accumulation of toxic substances in a food chain.



KNOWLEDGE

1 Organisms are affected by the surroundings they live in.

a What is another word for these surroundings? .....

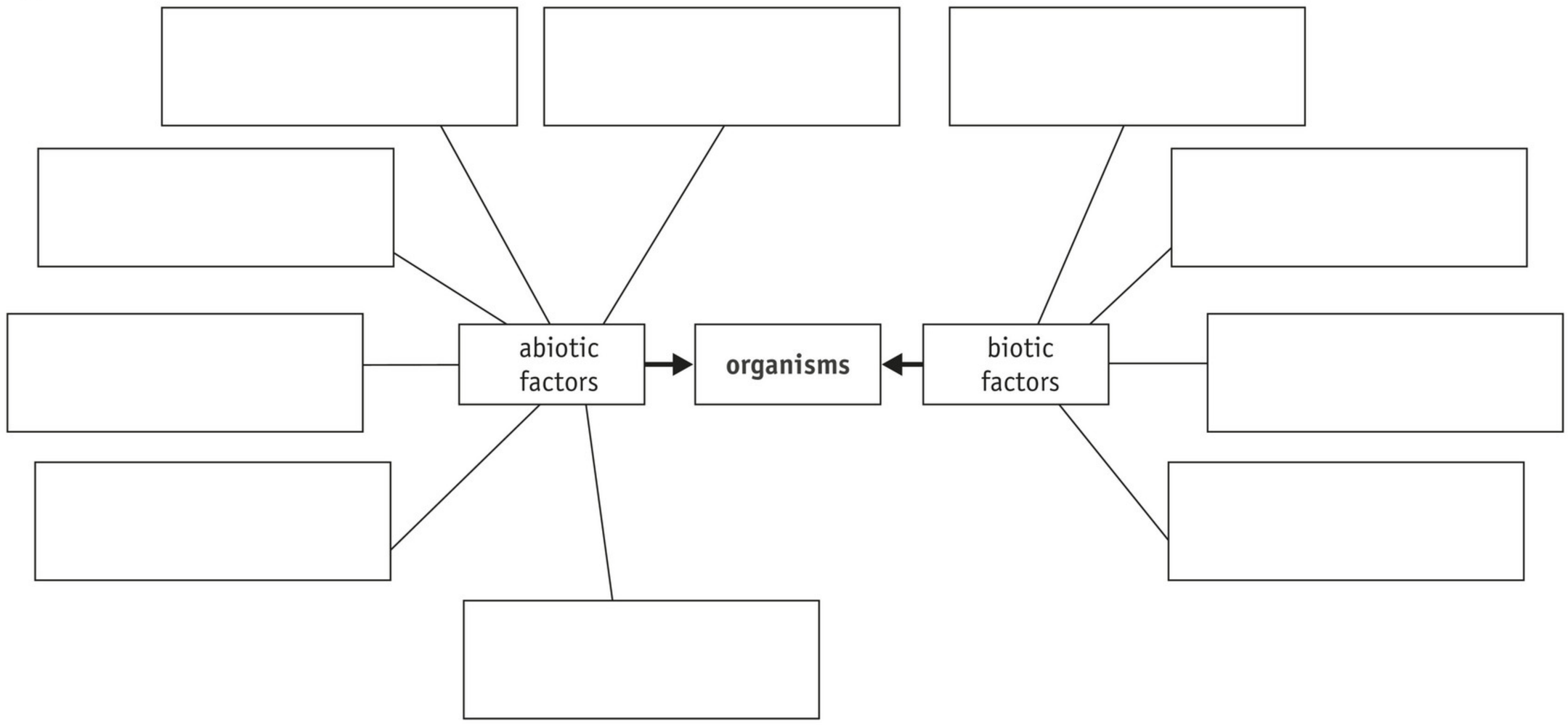
b What does ecology study?

c Algae are *an abiotic* / *a biotic* factor in a river.

d Oxygen is *an abiotic* / *a biotic* factor for fish.

e Fill in the table for figure 8. Use the following phrases: *soil – light – predators – others of the same species – temperature – food – water – wind – pathogens – oxygen*.

fig. 8



2

a What does a biotope consist of?

b Does a wolf belong to:

- an ecosystem? *yes / no*
- a biotope? *yes / no*
- a community? *yes / no*

c Link each level of ecology to the correct description.

A biosphere	○	○ 1	a specific area with all the organisms living in it, in which the biotic and abiotic factors form a unit
B ecosystem	○	○ 2	a group of organisms of the same species that live together in an area
C organism	○	○ 3	a living creature
D population	○	○ 4	the part of the Earth (and the air around it) where life is possible

d Put the levels of ecology in the right sequence, from small to large.

..... biosphere

..... ecosystem

..... individual

..... community

..... population

3

a What is the difference between a food chain and a food web?
b What is the first item in any food chain?
c You can see various different food chains in the food web in figure 5. The shortest food chain has three links and the longest has seven.
List two food chains from it that have three links.
d Write down the food chain from figure 5 that has seven links.
e Which animal from figure 5 is an omnivore? Explain your answer.

4

a What is biomass?
b Write down three groups of energy-rich substances.
c A food chain in the cattle farming sector has three links: grass → cow → human.
- The largest amount of energy-rich substances can be found in the *grass / cows / humans*.
- The smallest amount of energy-rich substances can be found in the *grass / cows / human*.

5

Summary

Biotic and abiotic factors

Biotic factors: .....

Abiotic factors: .....

Examples of abiotic factors: .....

.....

Levels of ecology

- Organism: .....
- .....
.....
- .....
.....
- .....
.....
- .....
- Biosphere: .....
.....

Feeding relationships

Food chain: .....

.....

The first link in a food chain: .....

Food web: .....

Accumulation: .....

.....

INSIGHT

6 After a shower of rain, you often see earthworms crawling up out of the soil. The environment (the rain) affects the earthworm.

a Earthworms come up out of the soil because of a change in *a biotic* / *an abiotic* factor.

b An earthworm also affects its environment.
Give an example of this.

c Some ecologists suspect the vibrations of the raindrops make the earthworms think a mole is coming. Moles are natural enemies of earthworms.
If the ecologists' theory is correct, are the earthworms trying to escape because of a change in a biotic factor, an abiotic factor, or both? Explain your answer.

7 There are lots of ponds in the dunes on Texel (see figure 9). Algae, sticklebacks, water beetles, water plants, water fleas and other things live in them.

- Are the organisms in one pond part of the same population? *yes* / *no*
- Are the organisms in one pond part of the same community? *yes* / *no*
- Is one such lake an ecosystem? *yes* / *no*
- Is the Texel duneland area an ecosystem? *yes* / *no*

fig. 9 Texel duneland area with ponds.

8

a A field yields about 10,000 kg of grass a year.
Can the cows become 10,000 kg heavier every year if they live exclusively on the grass in this field? Explain your answer.

b In poorer countries, people often have to live off a small plot of fertile land.
How can they get the most food from their plot of land?

○ A by growing crops on it
○ B by grazing livestock
○ C by growing crops on it and grazing livestock

c According to a report by the United Nations, 821 million people worldwide did not have enough to eat in 2017.
Some people say that there would be no need for anyone to go short of food if everyone was vegetarian. Explain how.

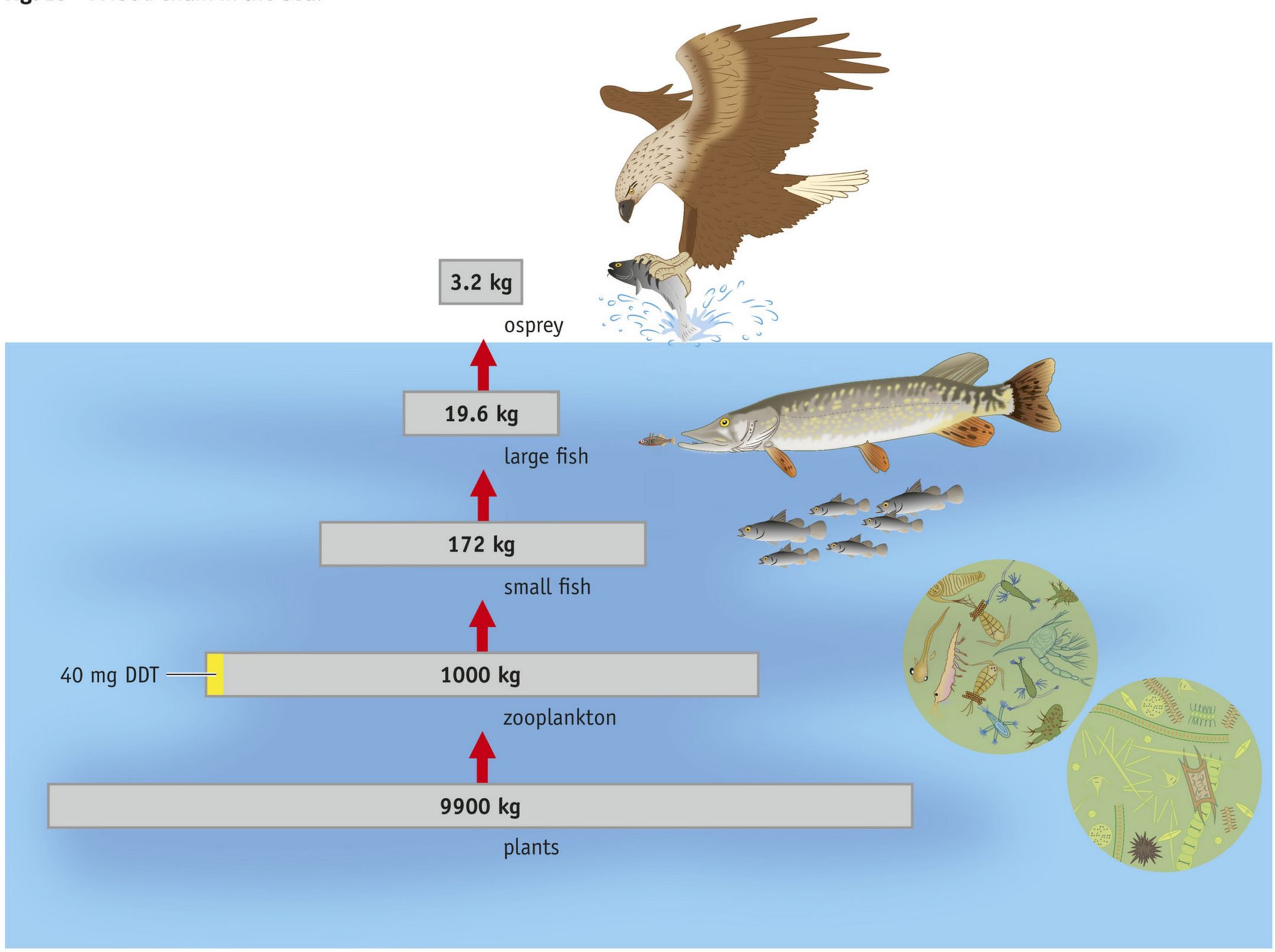
9 Figure 10 shows a food chain in the sea. The biomass of each link in the chain is given. A study into the amount of DDT (an agricultural pesticide) shows that the link containing zooplankton has 40 mg DDT per 1000 kg zooplankton.

a
- Write down in column 3 of the table how many milligrams of DDT each link has in total.
- Calculate the concentration of DDT per kilogram of biomass for each link. Write this down in column 4.

	Biomass	Total amount of DDT (in mg)	DDT per kg in biomass (in mg)
Osprey	3 kg		
Large fishes	20 kg		
Small fishes	175 kg		
Zooplankton	1000 kg	40	
Plants	10,000 kg		

b In the 1980s, a lot of seabirds died. The seals in the Wadden Sea were also threatened with extinction. The cause of death was very high levels of various toxic substances in the body, such as PCBs (substances from plastics and electronic devices), DDT and mercury.
Explain why seabirds and seals in particular die as a result of these toxins.

fig. 10 A food chain in the sea.



+ 10

a The biomass at each subsequent level of a food chain decreases. Explain why.

b In figure 6, the number of organisms gets smaller in each link. Is that always the case in a food chain? Explain your answer.

HOW IT FITS TOGETHER the living world

VELUWE WOLF PAIR FORMS A PACK

fig. 11 A wolf with pups.

A pair of wolves on the Veluwe have started a family. In June 2019, there were at least three pups. There is a chance that there will be many more. There is food in abundance. The wolves survive on their preferred prey: roe deer, boar, fallow deer, mouflons and other game animals. A lack of living space or water can slow down the growth of the wolf population. Wolf packs need about 200 km^2 of living space. The Veluwe is about 1000 km^2, so four to five packs could live there.
Wolves are at the top of the food chain, so they can make sure that the number of wild animals does not get too high. The vegetation of nature areas can also become more varied, as grazing ungulates will avoid areas because of the wolves. But there are also ecological threats. The number of mouflons might drop drastically. And they are the only animals that eat Scots pine and have been keeping open areas from becoming overgrown for over a century. If the mouflon were to disappear, it would reduce the biodiversity.
Sheep farmers are also worried. No sheep were killed in 2016. In 2017 there were 20 sheep killed, and in 2018 over 130. Experts say that people will not be attacked because wolves do not know that people can be food.

11 Read the text 'Veluwe wolf pair forms a pack'.

a In the text, highlight the *biotic* factor or factors that affect the wolves and underline the *abiotic* factor or factors that affect them.

b A wolf pack is a *biotope* / *ecosystem* / *community* / *population*.

c Which of the animals and plants referred to in the text belong to the wolves' community?

d Make a food web using the data in the text.

e Toxic chemicals such as drug synthesis waste are often dumped in nature areas nowadays.
What effect can such dumping have on the food web from Question (d)?

Go to the *Flash cards* and the *Test yourself* section.

2 Feeding relationships and cycles

LEARNING OBJECTIVES

6.2.4 You can describe the groups of organisms in the nutrient cycle.
6.2.5 You can describe the water cycle and the carbon cycle.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES				
	6.2.4	6.2.5	6.1.1*	2.1.2**	2.2.3**
Remembering	1abcd	2ab			
Understanding	1e, 2e, 4	2cde, 3, 4, 10a			
Using	5ab, 6, 10b	7, 8	10b		
Analysing	5c, 9, 10ce	9, 10d		9	10d

* You can find this learning objective in another Basics section.
** You can find this learning objective in another unit.

When an organism is eaten, the high-energy substances end up in the next link up in the food chain. In an ecosystem, every substance goes through a nutrient cycle.

PRODUCERS, CONSUMERS AND BREAKDOWN AGENTS

Photosynthesis takes place in plants. You can represent photosynthesis in an equation:

water + carbon dioxide + light → glucose + oxygen

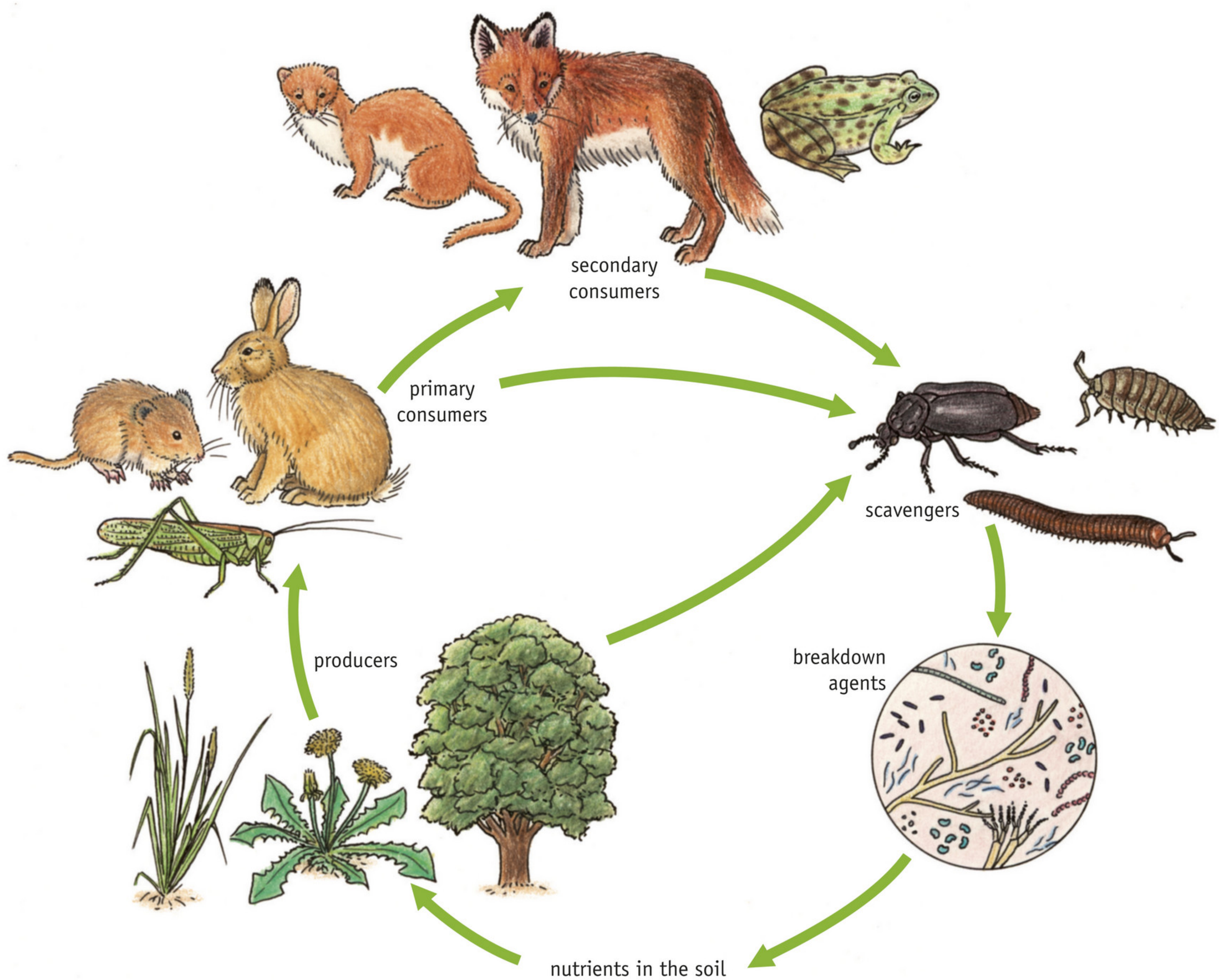
The glucose made by photosynthesis is used by the plant to produce the substances that it is made of. The plant also needs minerals (nutrients from the ground) to do this. Plants make (produce) the food for all other organisms. That is why we call plants **producers**. Producers are always the first link in a food chain.
Animals eat (consume) the substances made by plants. That is why animals are called **consumers**. Animals are the second and subsequent links in a food chain. Herbivores are the second link in a food chain and carnivores are the third and later links. In a food chain, the producers get eaten by the **primary consumers**. They in turn get eaten by **secondary consumers**, and so forth.

fig. 1 Scavengers.

Not all plants and animals get eaten. They can also simply die. The dead remains of plants and animals are used as food by **scavengers** (see figure 1). The remains left by the scavengers are broken down by bacteria and fungi. That is why bacteria and fungi are called **breakdown agents**.

In nature, all substances go through this type of **nutrient cycle** (see figure 2). Breakdown agents convert the substances from the dead remains of organisms into carbon dioxide, minerals and water. Carbon dioxide and water can in turn be absorbed by producers and used in photosynthesis. The minerals can also be absorbed by producers. The substances from the plants eventually end up in plants again, via animals, scavengers, bacteria and fungi.

fig. 2 The nutrient cycle.

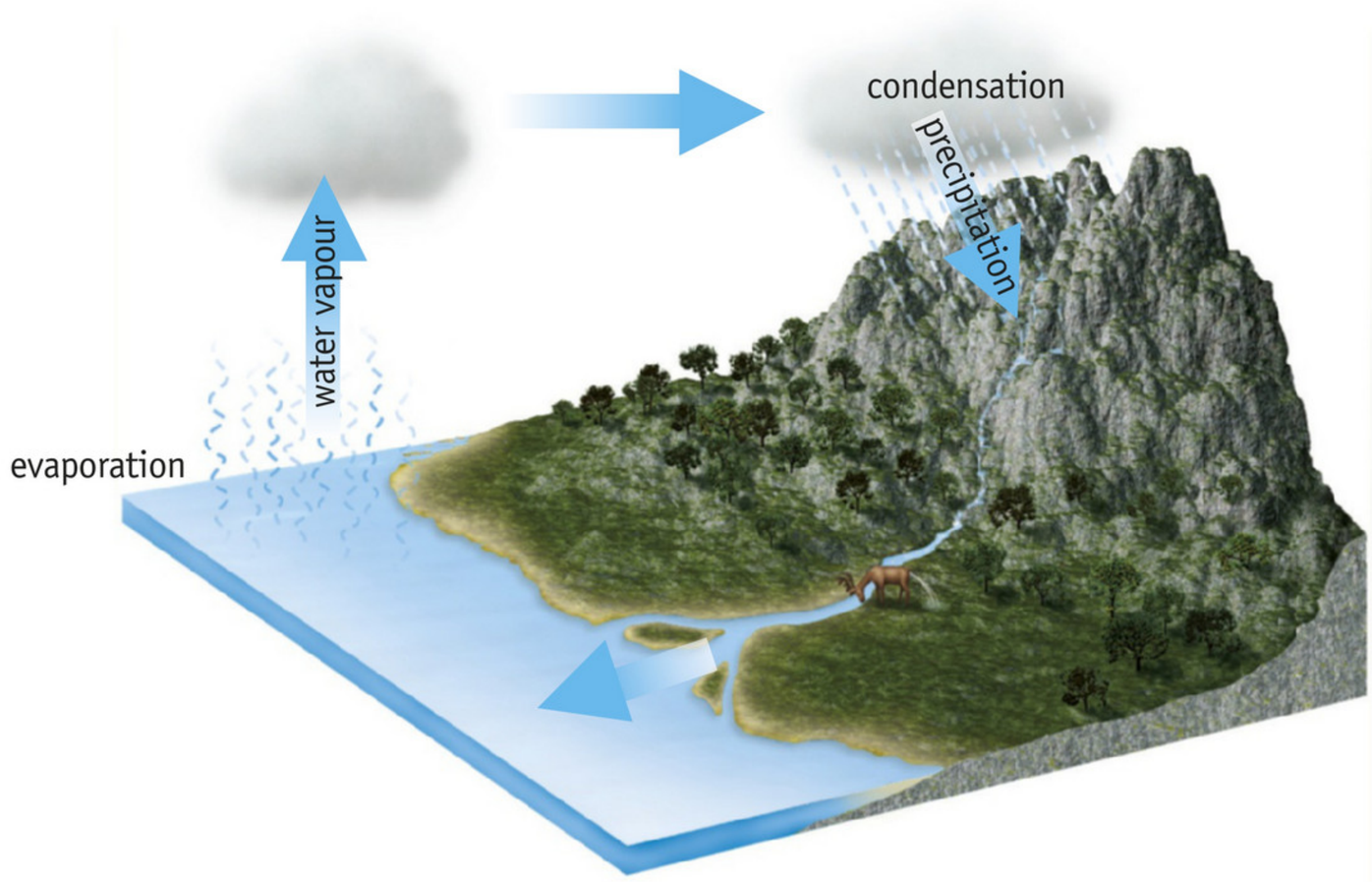


THE WATER CYCLE

All organisms need water to live. You take in water when you drink or eat. Water leaves your body through urine or sweat or by exhaling.
In nature, water goes through a nutrient cycle (see figure 3). Most of the water is found in the oceans and seas. Together they cover about 75% of the Earth's surface.

Water evaporates from the oceans and seas, especially when the weather is warm. This water vapour rises. It gets colder high up in the air, making the water vapour condense (form small droplets). This is how clouds form. When the droplets in the clouds get big enough, it starts to rain.
Water that has evaporated from the oceans and seas returns to the surface of the Earth as precipitation (rain, snow or hail). The water gathers in rivers and flows back into the oceans and seas.

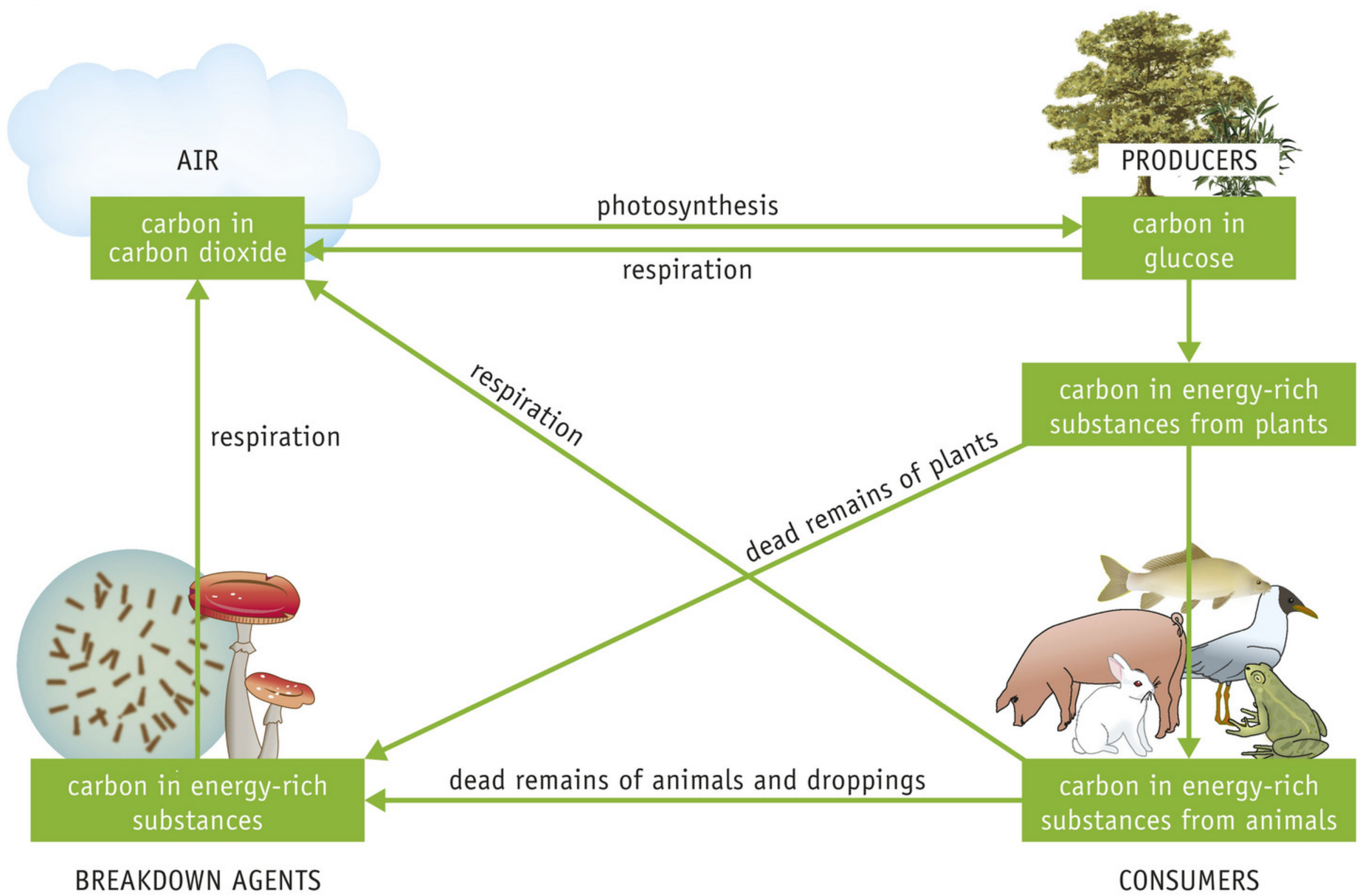
fig. 3 The water cycle.



THE CARBON CYCLE

Figure 4 is a diagram of the carbon cycle. This figure shows the forms in which carbon is present in the air, in plants, in animals and in bacteria and fungi.
The air contains carbon dioxide. Carbon dioxide is made up of oxygen atoms and carbon atoms. Plants absorb carbon dioxide from the air. During photosynthesis, they produce glucose and oxygen. The carbon from the carbon dioxide is then absorbed in glucose.

fig. 4 The carbon cycle.



Glucose is an energy-rich compound that your body uses as fuel. It releases the energy in the glucose. Plants also use some of the glucose they produce as fuel. In cells with no chlorophyll or in the dark, glucose is burned to release energy. This produces carbon dioxide, which the plants release to the air. The plant uses another fraction of the glucose produced to make various energy-rich compounds (proteins, carbohydrates and fats). This is how carbon atoms end up in energy-rich vegetable matter.

When a plant gets eaten by an animal, the energy-rich compounds from the plant get transferred to the animal. A proportion of these compounds is used as fuel in the body cells of the animal. This also produces carbon dioxide, which is released to the air. Another fraction of the energy-rich compounds is used as building materials. The carbon is now in the high-energy compounds of animals (proteins, carbohydrates and fats). The remains of the vegetable substances are not digested; this fraction leaves the bodies of animals in their droppings.

An animal in turn can get eaten by other animals (including humans). This is how the carbon can get transferred from one organism to another.
Plants and animals also die without getting eaten. The substances in the remains of dead organisms and in the faeces are taken in by breakdown agents. Bacteria and fungi use most of the high-energy substances they absorb as fuel for respiration. This produces carbon dioxide, which is released to the air.

BIODEGRADABLE AND NON-BIODEGRADABLE

Breakdown agents (bacteria and fungi) break down the waste and faeces from plants and animals. This is called biological degradation (or biodegradation for short). Waste from plants and animals is **biodegradable** (see figure 5.1).
People make products from parts of plants or animals. Waste from these products is biodegradable as well. Examples of this kind of waste are bread crusts and paper.
People also make products from glass, metal and stone. Waste from these products is not biologically degradable. This is called **non-biodegradable** waste (see figure 5.2).
Plastics made from petroleum are also non-biodegradable.

fig. 5 Waste.

1 biodegradable

2 non-biodegradable

PLASTIC SOUP

Every year, five to twelve million tonnes of plastic end up in the sea (see figure 6.1). Products made from synthetic materials persist in the environment for many years. Some plastics crumble into smaller pieces after a certain amount of time (see figure 6.2). In the major oceans, there are floating islands of plastic waste the size of France, some even larger. This is called the **plastic soup**. Some of this waste is clearly visible, but the smallest particles of plastic can no longer be seen. This is because the plastics get fragmented into microscopically small pieces (microplastics) under the influence of sunlight.

Crabs, fish and other animals see the plastic as food and eat it. This is how the plastic particles get into the food chain. In the end, the plastic goes up through the food chain into the bodies of predatory fish, birds and seals. Accumulation results in poisoning or disruption of the hormonal balance. Through fish and shellfish, the plastic can also get into the bodies of humans.

fig. 6 Every year, millions of tonnes of plastic get into the seas.

1 plastic soup

2 One kilogram of North Sea beach sand contains about 150 pieces of plastic.

KNOWLEDGE

1

a Which two substances does a plant need to produce the substances that it is made of?

b
- Scavengers are *consumers / producers / breakdown agents*.
- Animals are *consumers / producers / breakdown agents*.
- Plants are *consumers / producers / breakdown agents*.

c Which organisms are breakdown agents?

d
- A carnivore can be the *first / second / third or higher* link in a food chain.
- Herbivores can be the *first / second / third or higher* link in a food chain.

e In which links of a food chain can scavengers be present?

2

a Which gas in the air is part of the carbon cycle? .....

b In what substances does carbon occur in organisms?

c Some of the high-energy substances an animal eats are used as fuel in its body. In which substance can the carbon then be found?

d Some of the high-energy substances an animal eats are not digested. Where does the carbon from the high-energy substances end up successively?

e Which of these waste materials can be broken down by bacteria and fungi?
bread crust / egg shell / proteins / glass / carbohydrates / plastics / metal / paper / faeces / stone / fats

3 **a** Put these events in the carbon cycle in the correct sequence.

..... Bacteria and fungi release carbon dioxide into the air.

..... Bacteria and fungi consume energy-rich substances in their respiration.

..... Carbon dioxide is consumed and glucose is produced in photosynthesis.

..... Energy-rich substances from the animal are absorbed by bacteria and fungi.

..... An animal dies.

1 A plant absorbs carbon dioxide from the air.

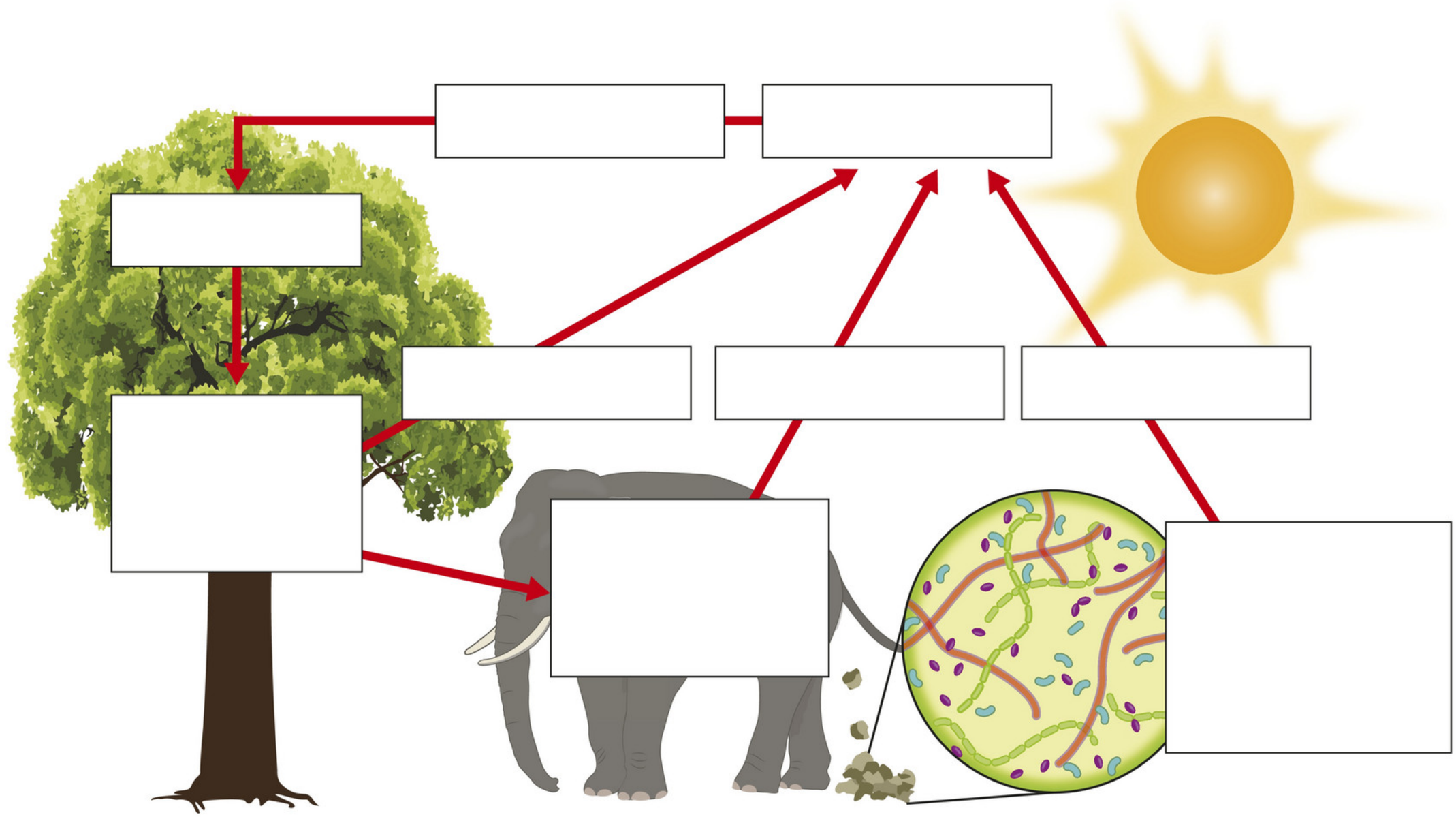
..... A plant is eaten by an animal.

..... Glucose is converted into energy-rich substances in the plant.

..... Energy-rich substances from the plant are converted into energy-rich substances in an animal.

b The drawing in figure 7 shows a part of the carbon cycle.
Fill the sections in. Use the following phrases: *energy-rich substances from an animal – energy-rich substances in bacteria and fungi – photosynthesis – carbon dioxide – energy-rich substances from a plant – respiration* (3×).

fig. 7 Part of the carbon cycle.



4

Summary

Draw flow diagrams of the nutrient cycle, the water cycle and the carbon cycle.

The nutrient cycle

The water cycle

The carbon cycle

INSIGHT

5 Figure 8 has been taken from a Ukrainian biology textbook. The figure represents a diagram of substances.

a What is in the sections?

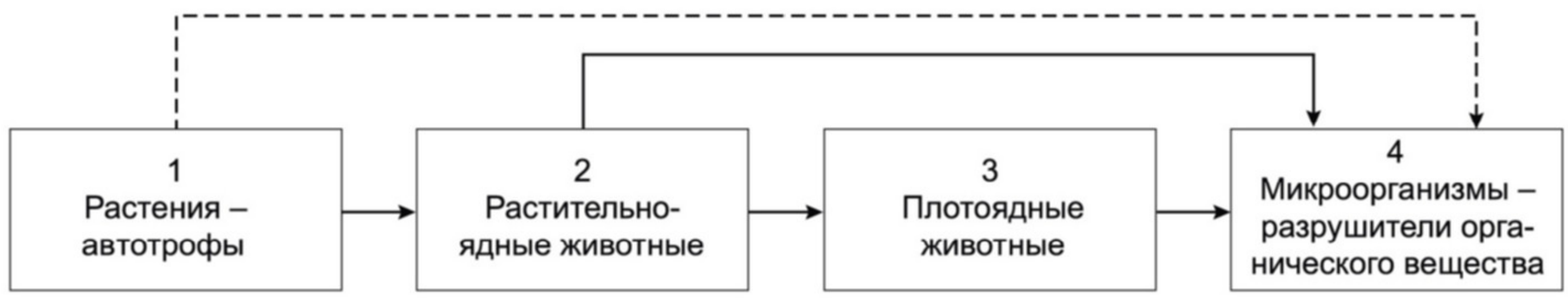
A	section 1 ○	○ 1	primary consumers
B	section 2 ○	○ 2	secondary consumers
C	section 3 ○	○ 3	producers
D	section 4 ○	○ 4	breakdown agents

b Herbivores belong to *section 1* / *section 2* / *section 3* and carnivores belong to *section 2* / *section 3* / *section 4*.

c What should be added to the Ukrainian diagram to turn it into a closed cycle?

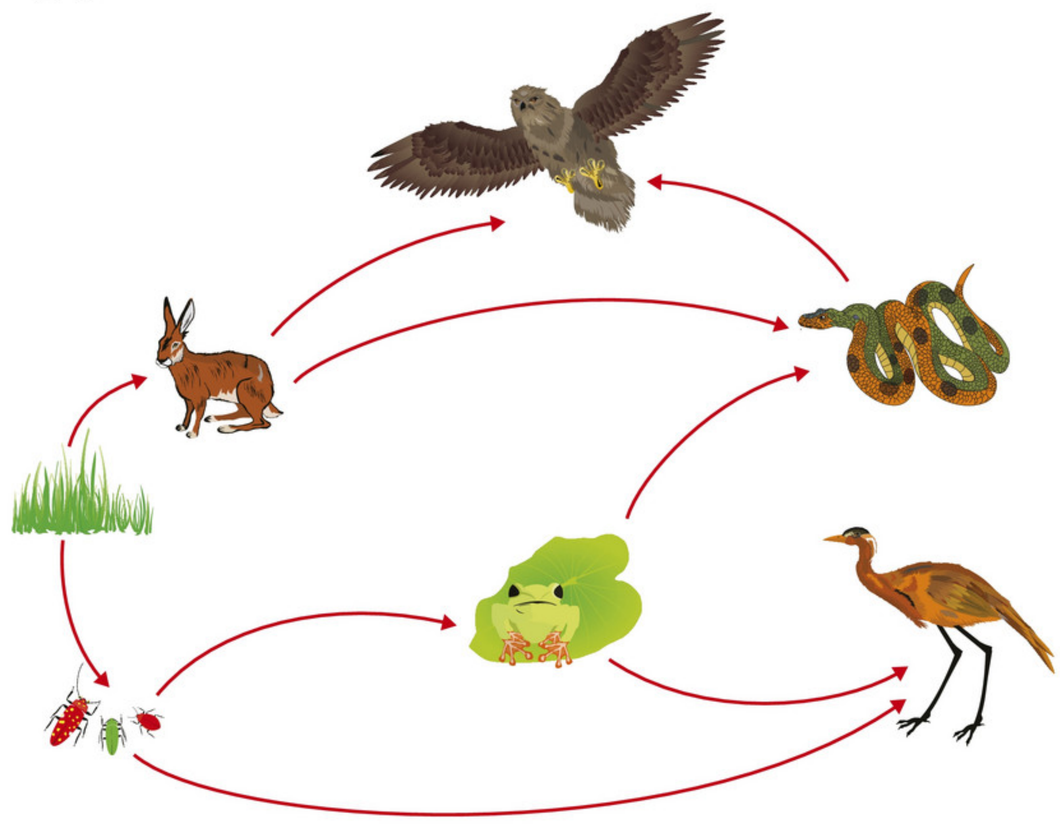
○ A scavengers
○ B minerals
○ C breakdown agents
○ D sunlight

fig. 8 Diagram of substances from a Ukrainian textbook.



6 An animal can be a multiple-order consumer.
Which animals in figure 9 can be both secondary consumers and tertiary consumers?
Explain your answer.

fig. 9 A woodland food web.



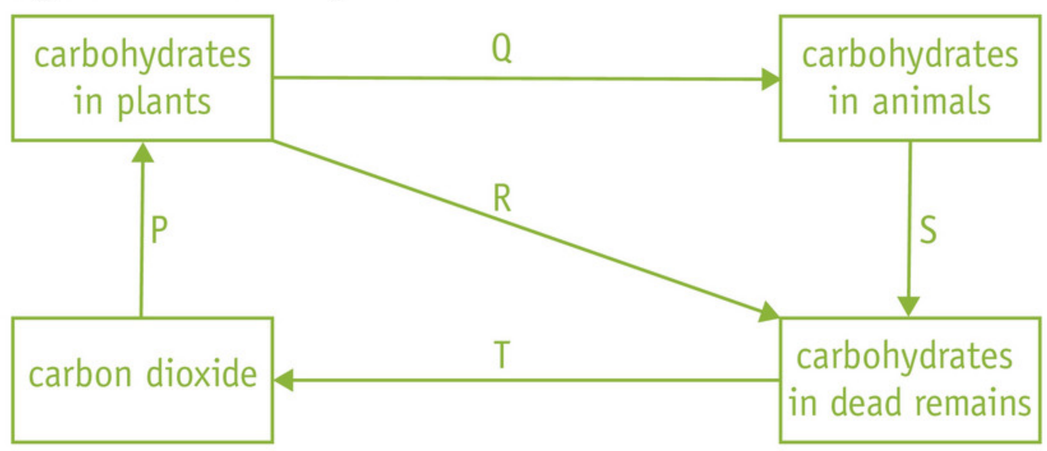
7 Figure 10 shows a diagram with several processes in the carbon cycle.

a Which arrow represents photosynthesis?

- ○ A arrow P
- ○ B arrow Q
- ○ C arrow R
- ○ D arrow S
- ○ E arrow T

b Which arrow represents the conversion by breakdown agents? Explain your answer.

fig. 10 A carbon cycle.



8 **a** Plastics contain carbon.
Explain that plastic is nevertheless not a part of the carbon cycle.

b Plastics get eaten by sea animals and birds.
Explain that despite that, plastic is not food.

+ 9 A dung beetle is a scavenger. The body of a dung beetle includes carbohydrates. The carbon atoms in the carbohydrates come from carbon dioxide that was in the air.
Describe how carbon atoms from carbon dioxide get into the carbohydrates of a dung beetle's body.

HOW IT FITS TOGETHER science

SEAWEED: THE PLASTIC OF THE FUTURE

The bioplastics of compostable packaging are often made from maize or sugar cane. You can throw this plastic in with the organic waste, after which microorganisms turn it into compost. Employees at the University of Plymouth in Great Britain investigated how biodegradable bioplastics really are. They buried all sorts of plastic bags in the ground, left bags hanging in the sea and exposed bags to the air.

Every nine months, the researchers noted the visible decay and decreasing tensile strength. After nine months in the open air, the compostable bags began to crumble apart, probably made brittle by UV light. The sample in the sea dissolved after nine months, but the one in the ground was still there after 27 months.

It is also possible to make bioplastics from seaweed. It seems that seaweed plastic breaks down much faster in nature. Some plastics can even be eaten. In 2019, edible water bubbles were distributed during the London Marathon (see figure 11). The casing around the water was made from seaweed. This saved no less than 200,000 plastic bottles.

Source: 'Biodegradable plastic supermarket bags do not appear to break down', René Didde, de Volkskrant, 30 April 2019.

fig. 11 Edible water bubble made from seaweed plastic.

10 Read the text 'Seaweed: the plastic of the future'.

a Bioplastics can be degraded by breakdown agents.
Does the carbon from the degraded bioplastic get into the carbon cycle? Explain your answer.

b The research by the University of Plymouth shows that plastic degrades less well in the cold ground than in the warm open air.
Explain this.

c The sea has no fungi and only a few bacteria.
Why might the degradation of bioplastics be faster in the sea than in the open air?

d A marathon runner eats a water bubble made from seaweed plastic.
Does the seaweed plastic get digested in the athlete's body? Explain your answer.

e Would seaweed plastic make the plastic soup in the world's oceans smaller? Explain your answer.

Go to the *Flash cards* and the *Test yourself* section.

3 Living together

LEARNING OBJECTIVES

6.3.6 You can explain what a biological equilibrium is.
6.3.7 You can explain how species depend on each other for food, shelter and reproduction.

► Practical activity 2

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES			
	6.3.6	6.3.7	6.2.4*	1.0.14**
Remembering		2abc, 3		
Understanding	1, 4	2d, 4, 7a, 10d		
Using	10a	5ab, 6a, 8ac, 10bc	8d	
Analysing	5d, 9	5c, 6b, 7bc, 8b. 10e		7b

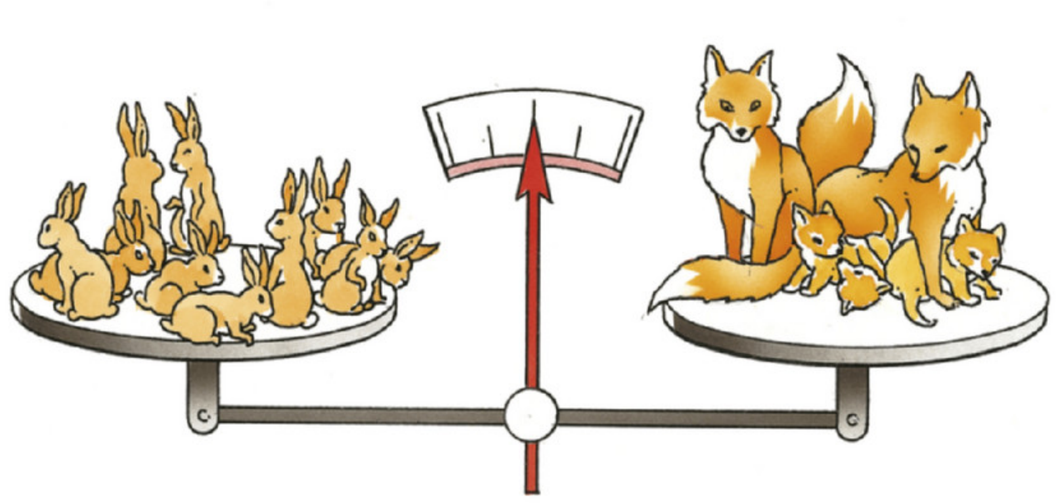
* You can find this learning objective in another Basics section.
** You can find this learning objective in another unit.

A population of a particular species in an ecosystem is not constantly the same size. In favourable circumstances a population can grow; in unfavourable ones, a population will shrink.

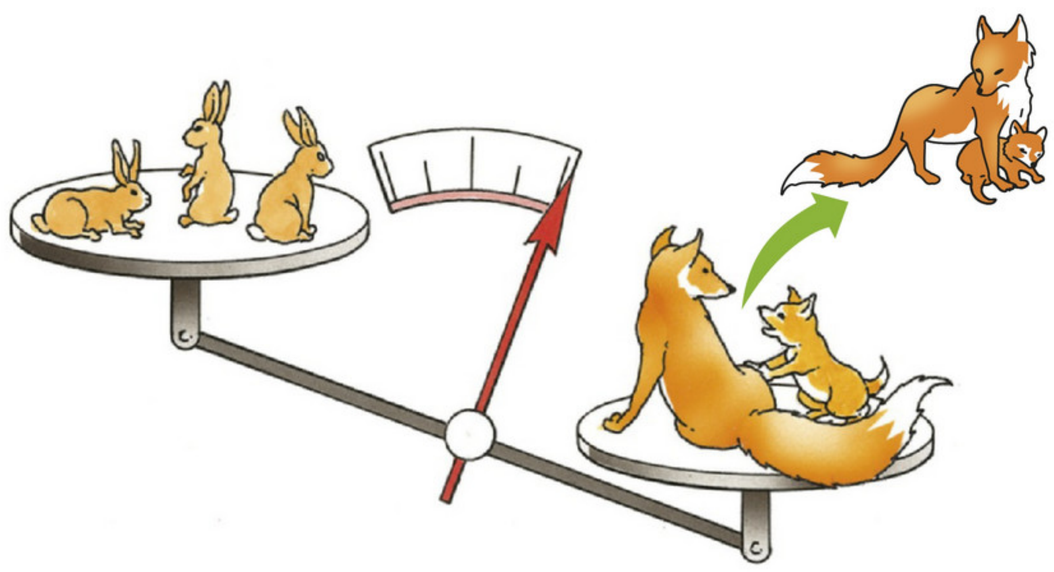
EQUILIBRIUM

The biotic and abiotic factors influence the size of a population. Biotic factors that influence a population can be the amount of food available, the number of natural predators and the pathogens present. Abiotic factors can include the soil, light, air (wind), temperature and water (rainfall).
If all the biotic and abiotic factors in an ecosystem are favourable for a population, the chances are that the population will grow – for example if there is enough food and very few natural predators. Unfavourable circumstances can mean that individuals die and that can make the population shrink.
The **population size** is the number of organisms of the same species living in a certain area. In many ecosystems, the populations sometimes grow and then shrink again. Most populations fluctuate from year to year around an equilibrium value. This is called a **biological equilibrium** (equliibrium means 'balance'). Figure 1 shows the biological equilibrium between rabbits and foxes.

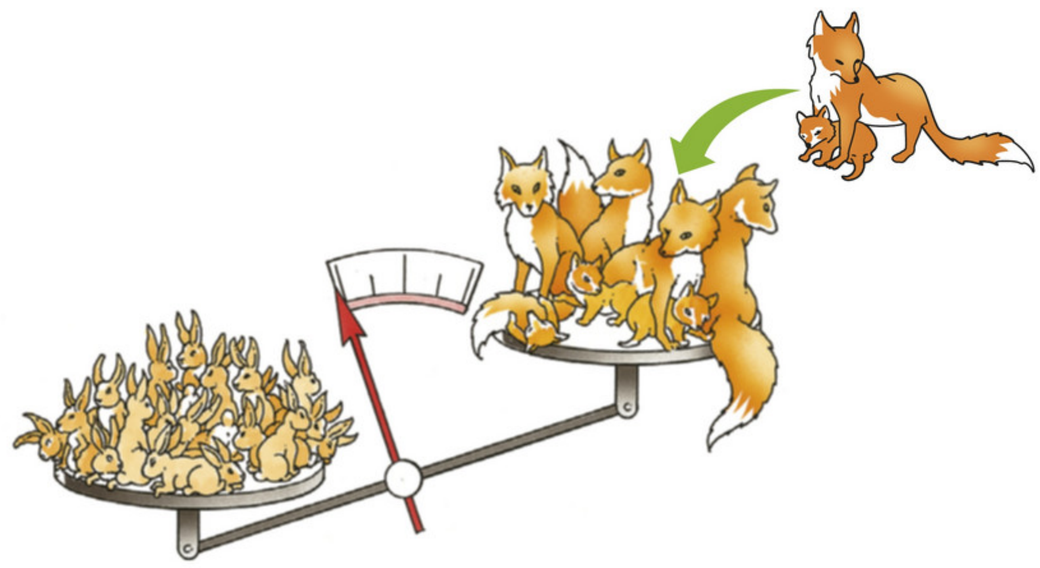
fig. 1 Biological equilibrium between rabbits and foxes.



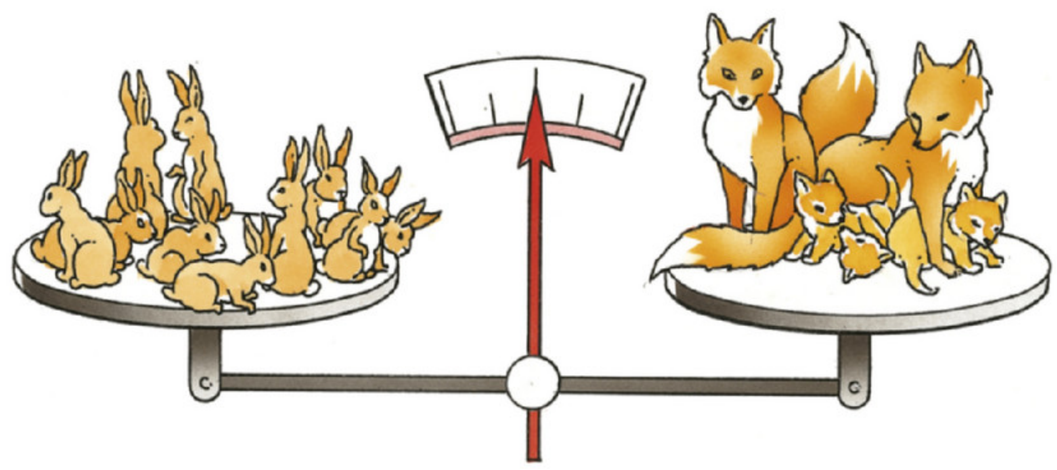
1st year: normal weather conditions: in balance



2nd year:
- grass grows poorly because of low temperatures and drought
- rabbits die because of a lack of food
- foxes leave for other ecosystems
- the foxes that remain do not bring up many young



3rd year:
- grass growth good because of warm and rainy weather
- rabbits have a lot of young
- foxes from elsewhere invade the ecosystem.



4th year: normal weather conditions: in balance

COEXISTENCE

Each individual within a population has relationships with many others of the same species. Individuals also have relationships with individuals of other species. There are also relationships between populations. A relationship can involve **competition** or **cooperation**. There is competition if individuals or populations are fighting for food, partners or safe places. An example of cooperation is a pride of lions who hunt for prey together (see figure 2).

fig. 2 Cooperation in lions.

RELATIONSHIPS WITHIN A POPULATION

Animals that live in groups often have a **hierarchy**. One animal is the boss, for example the oldest female in a herd of elephants. Every animal knows its place, so there are fewer fights. A territory also reduces the risk of fights. A **territory** is an area that is defended against members of the same species. A territory can serve as a hunting area, for instance, or as space for raising the young.

Individuals of the same species have to collaborate to reproduce. To reproduce, males and females **form pairs** (**pairing**). Some species form new pairs every year, but there are also species where the male and female remain a pair for life. This is the case in swans, for example (see figure 3).

fig. 3 A pair of swans with cygnets (the term for swan chicks).

RELATIONSHIPS BETWEEN SPECIES

There is often little competition between populations of different species because the species specialize. Kestrels, little owls and long-eared owls all eat field mice, but kestrels hunt during the day, little owls at dusk and long-eared owls at night. So they do not compete with each other.

Individuals from different species may have long-term relationships with each other. This form of coexistence is called **symbiosis**. There are various forms. Both species can benefit from the symbiosis. This is called **mutualism**. An example of this is lichen, where a fungus coexists with algae (see figure 4).
In other forms of symbiosis, only one of the two individuals benefits. If the other individual does not benefit and is not disadvantaged, we call it **commensalism**. An example of this is the green algae (Pleurococcus) on a tree trunk.
If one of the two individuals is disadvantaged by the coexistence, it is called **parasitism**. Here, one individual – the **parasite** – lives on or in an individual of a different species, the **host**. Parasites can be animals, plants or fungi (see figure 5).

fig. 4 The structure of a lichen (mutualism).

fig. 5

1 Tick. This arachnid feeds off the blood of animals and humans.

2 Dodder. This plant has no chlorophyll. It takes energy-rich compounds from the vessels of its host.

3 Zombie-ant fungus. This fungus eats ants slowly from within and can change the ant's behaviour patterns: the ants are made to look for a high place to die, making it easy for the fungal spores to spread.

KNOWLEDGE

1

a What is meant by the population size?
b Give an example of a biotic and an abiotic factor that can cause the population to change.
c When does a population grow? Use the words 'biotic and abiotic factors' in your answer.
d When is there a biological equilibrium in a particular area?

2

a In animals that live in groups, sometimes one animal is the boss and all animals know their place in the group. This is called a .....
b When reproducing, a male finds a female. This is called .....
c A male fish drives off other males from an area in the ditch and builds his nest there. This area is called a .....
d How can competition between members of the same species in a population be reduced? Write down two methods.

3

a What is meant by symbiosis?
b Write down three forms of symbiosis and describe the relationship between the organisms for each form.
c Organism 1 lives at the expense of organism 2.

- What do you call organism 1? .....
- What do you call organism 2? .....

4

Summary

Biological equilibrium: .....

.....

Population size: .....

.....

Relationships between individuals or populations:

- .....

  .....

- .....

  .....

Symbiosis: .....

- Mutualism: .....
- Commensalism: .....
- Parasitism: .....

INSIGHT

5 Figure 6 shows the key feeding relationships on a savannah in Africa.

a There is *competition* / *cooperation* between the rhinoceros and the giraffe.

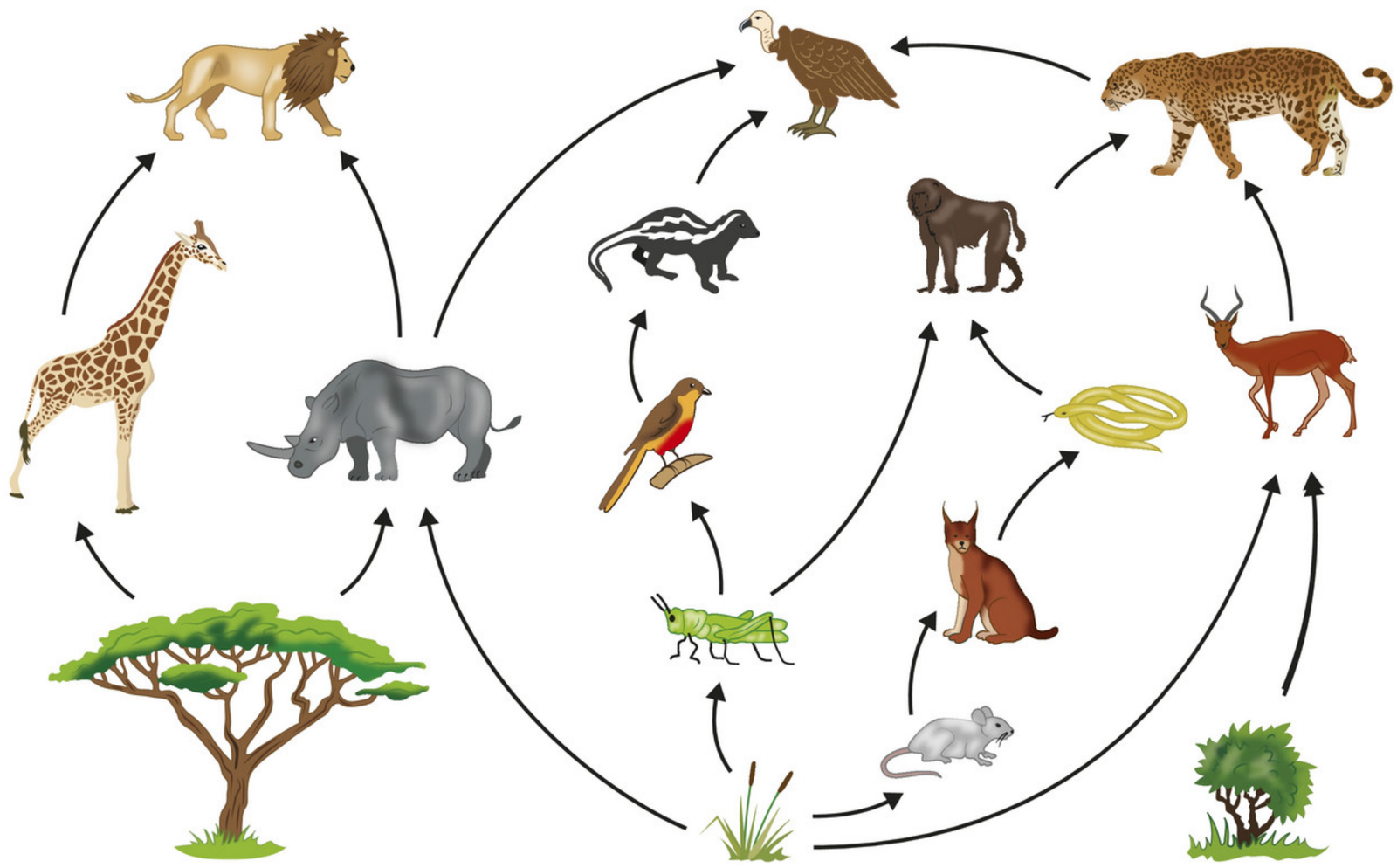
b Lions usually hunt in a group. Males that are outcasts and no longer belong to the group are called 'solitary' lions. These males live as nomads.

- There is *competition* / *cooperation* between lions in the same group.
- There is *competition* / *cooperation* between solitary lions and the group they were excluded from.

c Solitary lions usually live shorter lives than lions in groups. Explain this.

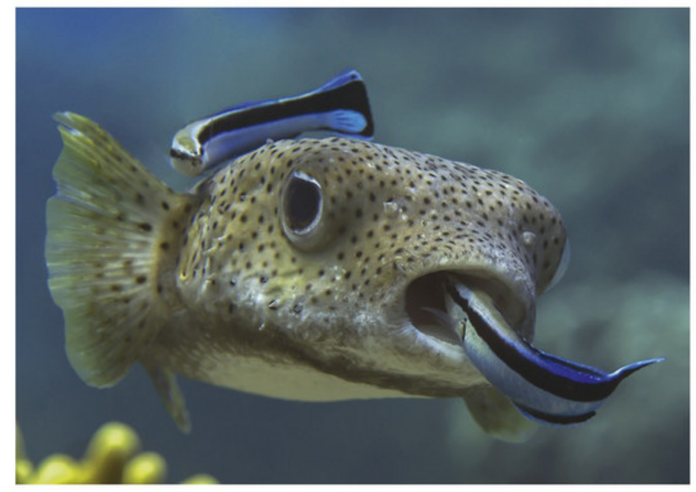
d If the number of rhinoceroses increases, the vegetation and the population sizes of other animals on the savannah change.
If the number of rhinoceroses increases, the amount of grass *decreases* / *increases*. This makes the number of mice *decrease* / *increase* and the number of locusts *decrease* / *increase*. The number of giraffes *decreases* / *increases* and the number of vultures *decreases* / *increases*.

fig. 6 Feeding relationships on a savannah in Africa.



6 Cleaner fish (*Labroides dimidiatus*) are fish that remove parasites from the body surface, gills, and even the inside of other fishes' mouths (see figure 7). They eat the parasites. Wounded or sick fish let themselves get treated several times per day. This takes place at a sort of cleaning station. Fish that want to be cleaned show that by a certain swimming movement or a specific posture, such as a vertical position.

fig. 7 A pufferfish (*Diodon hystrix*) gets cleaned by cleaner fish (*Labroides dimidiatus*).



a What type of relationship is it that a cleaner fish has with the other fish species? Explain your answer.

b The fish species *Aspidontus taeniatus* looks a lot like the real cleaner fish. This lets it get close to a fish that wants to get cleaned. But instead of cleaning, it bites healthy bits of skin from fins, mucus or scales and then quickly swims away from the – usually annoyed – victim.
What type of relationship is it that *Aspidontus taeniatus* has with the other fish species? Explain your answer.

7 According to a myth, there is supposedly a symbiotic relationship between the Nile crocodile and the Egyptian plover (*Pluvianus aegyptius*), a small bird. The birds are said to pick food residues and leeches from the mouth of the Nile crocodile. That relationship has never been captured on photo or video, so it is not proven.

a What symbiotic relationship is there between the Egyptian plover and the Nile crocodile according to the myth? *commensalism* / *mutualism* / *parasitism*

b Suppose that an ecologist managed to take a photograph of an Egyptian plover in the mouth of a Nile crocodile.
Does this prove that there is a symbiotic relationship between the bird and the crocodile? Explain your answer.

c A pupil says there is a symbiotic relationship in the mouth of the Nile crocodile, but not with the Egyptian plover.
What symbiotic relationship does this pupil mean?

fig. 8 Broomrape.

8 Broomrape is a parasitic plant (see figure 8). The botanical name is *Orobanche*, which means something like 'pea strangler'. Broomrape is a very rare and protected plant in the Netherlands and Belgium.

a Like many parasitic plants, broomrape has no chlorophyll. Explain why not.

b Which part of the host does the broomrape take its nutrients from? Explain your answer using figure 8.

c Most parasitic plants do not kill their hosts. Explain why not.

d Is broomrape a producer? Explain your answer.

+ 9 To estimate the population size, the catch-and-release technique is used. A number of animals in an area are caught. This is the first catch. These animals are given a mark, for example a ring around a leg. The animals are then released and allowed to mix with the unmarked animals in the population. Some time later, a few more animals are caught: the second catch.
You can calculate the population size as follows:

$$\frac{\text{number of marked animals in the second catch}}{\text{total number of animals in the second catch}} = \frac{\text{total number of animals in the first catch}}{\text{entire population (P)}}$$

a Turn this comparison into a formula to make it easier to calculate the entire population size P (P = ...).

b 52 animals from a population of frogs are caught. These animals get a small elastic ring around a leg. They are then released back into the population. A week later, more frogs are caught: 43 animals. 13 of these animals are marked.
How many frogs does this population consist of? ..... frogs

c The rings that the frogs were given around their legs turn out to be too tight. The ringed frogs are now slower than the other frogs and are more easily caught. The calculated population size is therefore different from the actual population size.
The calculated size is *larger* / *smaller* than the actual population size.

d A population of birds is estimated to be 500,000 individuals based on the catch-and-release method. A few birds were caught, given a ring around the leg and then released again. In the second catch, 2496 animals were caught, of which 25 were ringed.
Roughly how many birds were in the first catch?
250 / 500 / 2500 / 5000

HOW IT FITS TOGETHER the living world

WARNING: OAK PROCESSIONARY CATERPILLARS!

The caterpillars of the oak processionary moth are becoming a pest in many places in the Netherlands. These caterpillars eat the leaves of oak trees. When the caterpillars shed their skins in May or June, their hairs end up in the air. Once shed, the hairs can float around and remain active for years. These hairs can make people itchy, cause rashes or result in inflamed eyes or lungs.

Researchers think that the plague is being caused by climate change and the lack of biodiversity in road verges. Many roads in the Netherlands are lined with oaks, with a tree every five to ten metres. Other vegetation in the road verge is often mowed away. This makes it very easy for the oak processionary caterpillar to spread, grow and reproduce.

According to ecologists, it is important to bring back biodiversity by leaving the verges alone. This will result in more natural enemies such as parasitic wasps and parasitic flies. These natural enemies lay their eggs in the oak processionary moth caterpillars. The larvae eat the caterpillars from the inside out. Other natural enemies are birds, such as nuthatches, great tits and the cuckoo. Nuthatches and great tits first shake all the poisonous hairs off the caterpillars. The cuckoo has an adapted digestive tract and eats the caterpillars whole, with skin and hair.

Source: https://nos.nl.

fig. 9 Oak processionary caterpillars.

10 Read the text 'Warning: oak processionary caterpillars!'.

a Is there a biological equilibrium of oak processionary caterpillars? Explain your answer.

b Glenn says, "There is competition between the parasitic wasp and the other natural enemies of the oak processionary caterpillar."
Explain why Glenn is right, but that there is little competition in practice.

c is there competition for food within a group of oak processionary caterpillars? Explain your answer.

d Biologists have seen that the oak processionary caterpillars have a leader: "If it dies, the other caterpillars hold a meeting to decide on a new leader. They all sit there with their back ends up in a circle, which is very funny to see," said a biologist in an interview for a newspaper.

What is a description of behaviour called in biology? .....

e Explain why the biologist from Question (d) might use the term 'meeting' to a journalist, but that they would never write that in a scientific report about behaviour.

Go to the *Flash cards* and the *Test yourself* section.

4 Nature management

LEARNING OBJECTIVES

6.4.8 You can explain that a lot of nature in the Netherlands was created by human intervention.

6.4.9 You can list ways in which people in the Netherlands manage, protect and restore nature.

- Learning how to do research 2
- Practical activity 3

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES		
	6.4.8	6.4.9	6.1.1*
Remembering	1	2ab, 3ac	
Understanding	4	2c, 3bd, 4	
Using	5, 6, 8a, 11b	5, 6a, 7a, 9ab, 11ac	11d
Analysing	8bc, 10	7bc, 9c, 11e	7c

* You can find this learning objective in another Basics section.

People try to protect nature through nature management. Some people even say that there is no real nature in the Netherlands anymore because you can see the influence of humans everywhere.

PEOPLE AND THEIR ENVIRONMENT

Like all other organisms, humans depend on their environment (see figure 1).

fig. 1 Humans are dependent on their environment.

People get food, water and oxygen from their environment. We also get energy from the environment, for example for cooking, heating our homes and operating machinery. The natural environment also provides raw materials. Raw materials are used for making products. Iron ore is used for producing steel, petroleum is used for making plastics and wood is used to make furniture. Finally, nature is important as a place for recreation. People use nature as somewhere to relax in their free time (see figure 2).

fig. 2 Nature as a place for recreation.

FORMATION OF THE LANDSCAPE

When you travel through the Netherlands, you can see flat pastures, ploughed fields, broad rivers, high dykes, straight ditches, rows of trees and many roads and built-up areas (see figure 3). The Dutch landscape was largely formed by humans. It is a **cultural landscape**: one that arose under human influences. People are affecting the landscape in various ways (or did so in the past). Important influences are agriculture, energy generation and water management.

fig. 3 The Dutch landscape (near Hoogeveen).

Two thirds of the land surface in the Netherlands is used by **agriculture**; a little over half of that is grassland. About 12% of the Netherlands' land surface is woodland. All the woods in the Netherlands were planted, for example for forestry. In **forestry**, woodlands are used for producing wood as fuel and building material.
In some parts of the Netherlands, the soil is very wet. In these areas, you mainly find pastures with a lot of ditches for draining water. As well as ditches, the Netherlands has a lot more water bodies: the North Sea, the IJsselmeer, rivers, lakes and canals. To protect the land from flooding, dykes and sluices were built and the rivers were deepened. So you can see the influence of humans everywhere in the landscape.

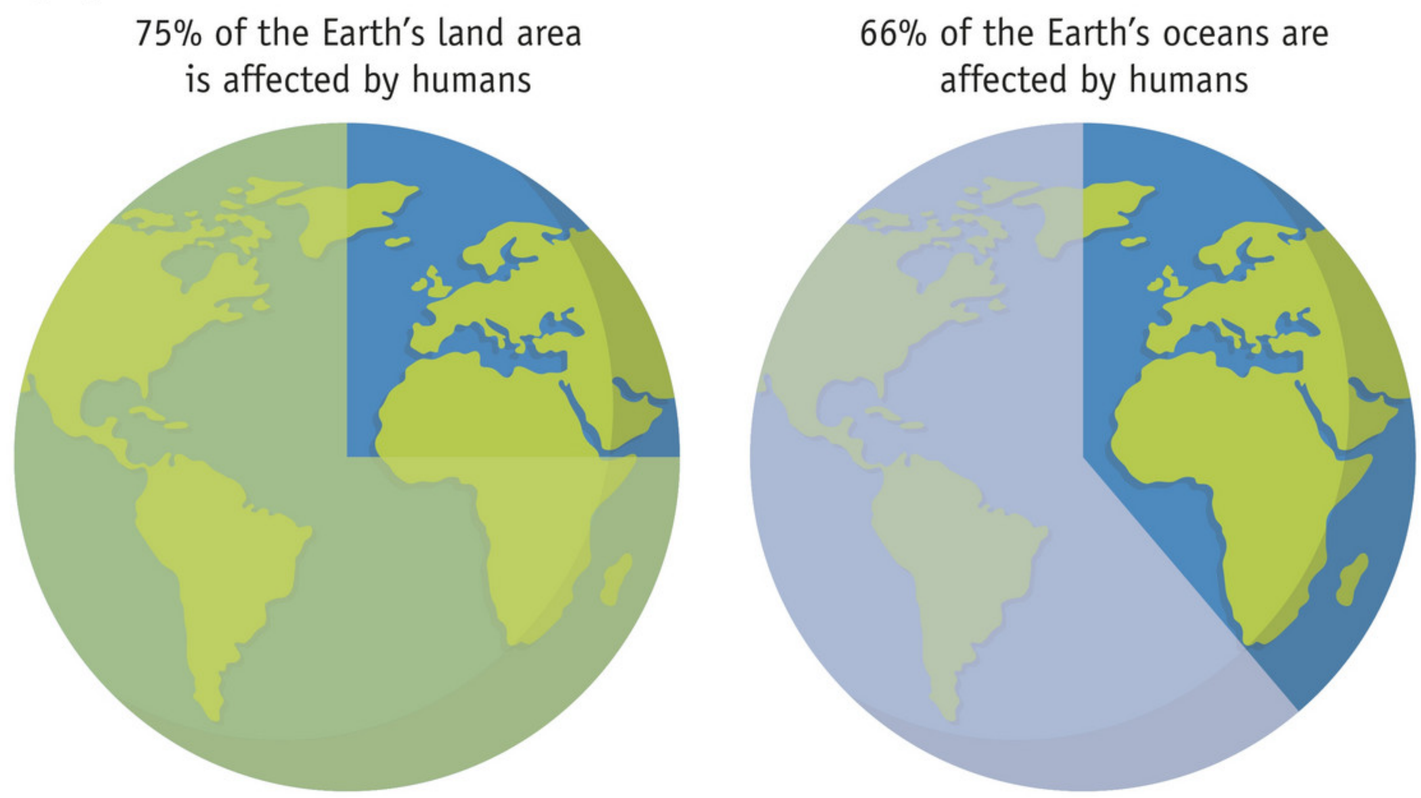
BIODIVERSITY

Around the world, people use a lot of land and water for agriculture, livestock farming, fishing, buildings, transport and extracting raw materials. Most of the land area (75%) has been dramatically changed by people. Almost all the oceans and seas (97%) are affected by people. In 66% of the Earth's oceans, the consequences are clearly visible (see figure 4). Over a third of the Earth's land area is used for agriculture and livestock farming, as well as almost three quarters of all freshwater sources.

Human activity is making the natural habitats of plants and animals get smaller or disappear entirely. The number of different ecosystems around the world is decreasing. Numerous species are now **endangered**. Individuals of these species have trouble staying alive and reproducing. Eventually, this can make a species go **extinct** (disappear entirely).
As a result, there is less and less variation in nature. The variation of species in nature is referred to as **biodiversity**. Biodiversity is decreasing due to the impact of people.

A total of eight million species of animals and plants are estimated to live on Earth. About a million of these could become extinct if we do not take action. The decline in biodiversity is a threat to humans because we need nature if we are to survive, for example for food and medicines.

fig. 4 Human influence.

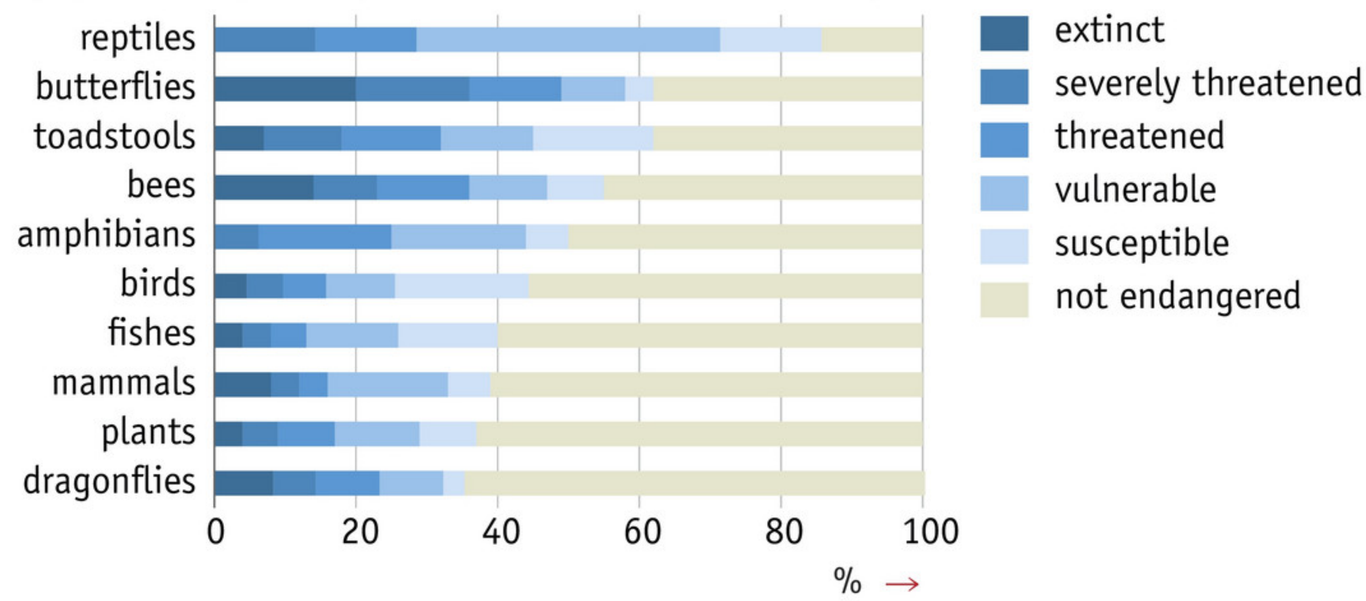


Source: IPBES Global assessment report on biodiversity and ecosystem services, Summary for policymakers, 2019.

REINTRODUCTION

Many plant and animal species in the Netherlands too are threatened with extinction (see figure 5). Protective measures are being used to try to increase the populations of endangered species. For example, the stork population in the Netherlands was in serious difficulty sixty years ago, which is why a project was started to increase the number of breeding storks. There have also been projects for reintroducing beavers, otters, European bison and sturgeon (a fish species) in the Netherlands. **Reintroduction** means bringing an animal or plant species back into a country. Most of these measures have been successful: the stork is no longer on the list of endangered bird species and the number of beavers in the Netherlands is estimated at roughly 3500. It remains to be seen if the otter will settle permanently in the Netherlands again.

fig. 5 Endangered species in the Netherlands (2019).



Source: organizations for the various species, WUR, Compendium for the Living Environment.

NATURE MANAGEMENT

Reintroducing endangered species is a form of nature management. Examples of **nature management** are all the measures that are meant to preserve, protect and restore nature in the Netherlands. 'Nature' usually means all areas not used for living, working, agriculture or traffic. Only 15% of the Dutch land area is nature; a large proportion of that is woodland.

An example of nature management is the construction of passages for wildlife from one nature area to the other (wildlife crossings). Figure 6 shows more examples of nature management in the Netherlands.

fig. 6 Nature management measures.

Agricultural nature management	Forest management
 field verge with flowers Farmers can get subsidies if they take measures to protect nature. Measures include: • sowing flowers alongside fields so that insects can live there; • mowing pastures later so that meadow birds' nests do not get destroyed; • using less fertilizer so that less of the harmful substances get into the soil and water; • digging ponds where amphibians can live.	 Highland cattle in the woods at Dorst *Staatsbosbeheer* (the National Forestry Commission) looks after plants and animals by preserving diversity in forest vegetation. Dutch woodlands have open terrain as well as trees. You can often find different plants and animals on this open terrain than in the woods. Cutting down trees gives other trees more space or prevents heathland from disappearing. *Natuurmonumenten* (the Society for the Preservation of Nature in the Netherlands) is also active in woodland areas. One measure in forestry is using animals for grazing. It lets an area retain its natural vegetation. This often leads to an increase in biodiversity.
Fauna management	**Water management**
 wild boars The fauna is the term for all the animal species that live in an area. Fauna management consists of measures to preserve healthy wildlife populations and prevent damage by populations that are too big. This can be done for example by reintroduction, but shooting (hunting) is also a management method. Examples include: • shooting foxes to protect meadow birds; • shooting sick and weak deer to spare them suffering; • shooting wild boars to prevent damage to crops (if there is no other way); • shooting geese if they become a hazard to air traffic safety at Schiphol Airport.	 sluice in the canal at Waalwijk *Rijkswaterstaat* (the Directorate-General for Public Works and Water Management) and the water boards manage the water in the Netherlands, including the rivers, the canals and the groundwater. Water management includes measures to manage the groundwater and surface water, such as: • cleaning up water pollution from stream and river beds; • creating passageways for fish in sluices and dams; • widening rivers to reduce the risk of flooding; • making banks less steep so that water plants and riverbank plants can grow better; • opening sluices slightly to create a natural transitional area between seawater and river water.

KNOWLEDGE

1 People use their natural environment for recreation.

a Write down five other ways people use the environment.

b Give at least three examples of activities where people use energy.

c Write down three ways in which people in the Netherlands created a cultural landscape.

2 **a** If a population of a species shrinks strongly over a long period, the species becomes ..... Eventually this can make a species become ..... (disappear entirely).

b What is biodiversity?

c What causes a decrease in biodiversity?

3 **a** What is the purpose of reintroduction programmes?

b What does nature management mean?

c List at least four organizations or professions of people who are involved in nature management in the Netherlands.

d Connect each form of nature management with the associated measure.

A	agricultural nature management	1	shooting wild boars
B	forestry	2	using animals for grazing
C	fauna management	3	making banks less steep
D	water management	4	mowing pastures later

4 **Summary**

People use their living environment for .....

.....

Cultural landscape: .....

.....

.....

Nature: .....

Biodiversity: .....

Nature management: .....

.....

.....

Examples of measures:

.....

.....

.....

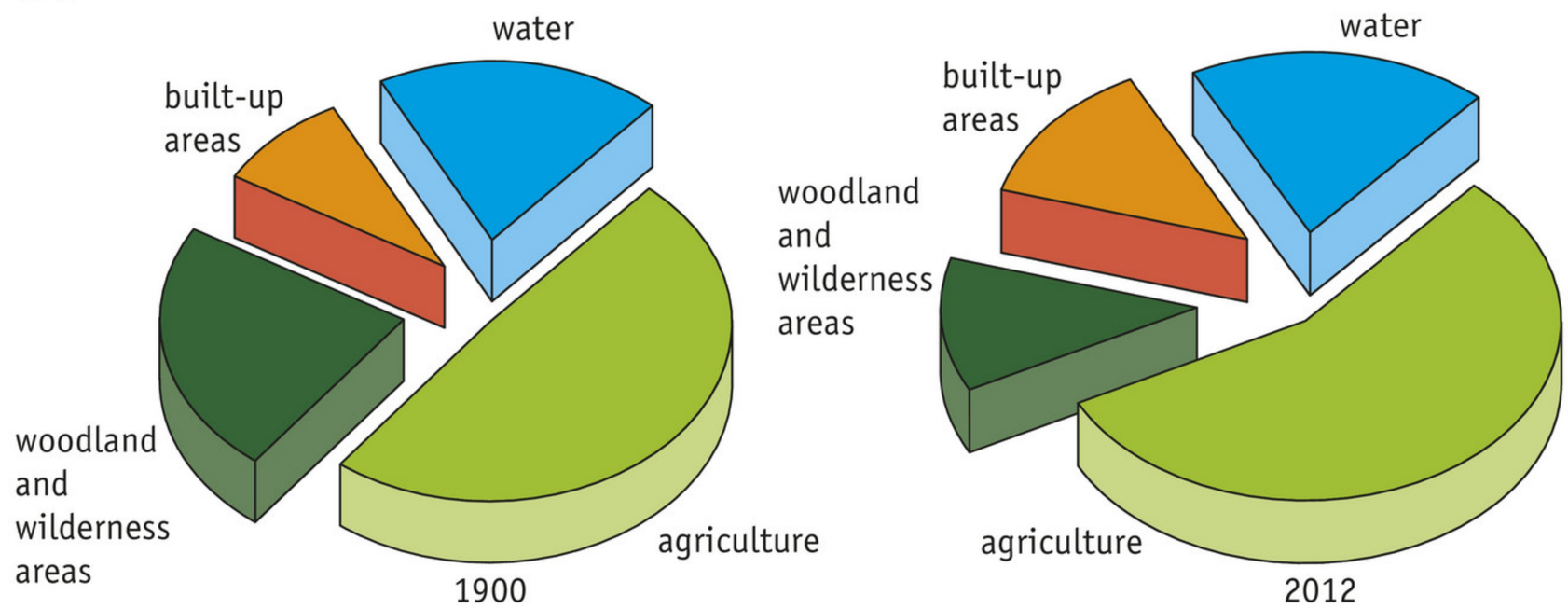
.....

.....

INSIGHT

5 Figure 7 compares land use in the Netherlands in 1900 and in 2012.
What change in land use has resulted in reduced biodiversity?

fig. 7 Land use in the Netherlands.



6 In Flevoland, after the land was reclaimed, a large marshland area appeared with grassland, freshwater lakes, reeds and marsh woodlands: the Oostvaardersplassen. All kinds of animals migrated to this area for food and to reproduce. To prevent the area from becoming overgrown with trees, people introduced wild heck cattle, Konik horses and red deer. The groundwater level is also managed by humans. If we did not, the area would dry out. The landscape would change and become unsuitable for many birds. We also let nature take its own course in the Oostvaardersplassen. The area is not accessible to the public.

a Are the Oostvaardersplassen a cultural landscape? Explain your answer.
b Are the Oostvaardersplassen a nature area? Explain your answer.
c The IJsselmeer used to be an inland sea called the Zuiderzee. The Afsluitdijk (the dyke closing the area off) changed this sea into a freshwater lake.
Is the IJsselmeer a nature area or a cultural landscape?

7 Fauna management means that animals are regularly shot in the Netherlands. This keeps the population healthy by killing off sick animals. The hunters who do this are in a way taking over the role of larger predators such as the wolf. These predators are practically absent in the Netherlands.
In 2018, healthy deer in the Oostvaardersplassen were killed by hunters because the population had become too big, leading to a shortage of food for them.

a Explain why shooting deer eventually solved the food shortage.
b Do you think hunters should be allowed to kill deer for that reason?
c A species is reintroduced in an area.
What must this area also have if a plague of that species is to be prevented?

8 The Pampas in South America is a vast, natural grass plain (see figure 8). The area is 800,000 km² in total. Farmers let their cows graze on parts of the plain.

a Are the parts where farmers let their cows graze used for livestock farming? Explain your answer.

b About 75% of the Earth's land area has been dramatically changed by humans. Does this include the grazed areas of the Pampas? Explain your answer.

c Are the Pampas a nature area or a cultural landscape? Explain your answer.

fig. 8 Cows on the Pampas.

9 The verges alongside roads are maintained by people. If they are mowed regularly, the verges will mainly have a lot of grass. If the verges are only mowed late in summer, there will be verges with a lot of flowers. This is because the plants will get the time to make seeds and as a result they can grow again in large numbers the next year.

a Which form of verge maintenance is more favourable for insects? Explain your answer.

b Which form of verge maintenance leads to greater biodiversity? Explain your answer.

c Grass from the verges is used for generating energy. Verges are regularly mown and the cuttings are fermented along with animal manure and some other materials. The fermentation process releases biogas and fertilizer is left over at the end.
What do you think: is mowing the verge regularly a good form of nature management? Give at least two arguments for your opinion. Discuss your position with a classmate.

+ 10 A piece of plastic is floating in an ocean area where people have never been.
Is this ocean affected by human activity? Explain your answer.

HOW IT FITS TOGETHER biology in professional life

ECOLOGY AND ENVIRONMENT ADVISER

Rietje Klous is an ecology and environment advisor at the engineering consultancy Sweco. Sweco is a Swedish company with branches in seventy countries, including the Netherlands. "The ecosystem of our planet is playing an increasingly important role in area development. Together with my colleagues, I make sure that building projects meet all the regulations and have all the correct licences. After training to become a zoological analyst, I studied Environmental Protection at Wageningen University.

I do lots of different things in my work. For instance, we make sure that building is done as sustainably as possible and that area development does not harm biodiversity but improves it instead. We do this by including nature in the building work. This means that when designing a residential area we already make it suitable for as many species as possible. For example, when building some houses, bat roosts are built into the walls, or measures are taken to allow house sparrows to build nests under the roofs. When planting greenery in a residential area, we give advice about planting flowers and bushes to attract bees, butterflies and other insects.

Space is scarce in the Netherlands. Over the coming years, thousands of homes will be built. I love being able to help restore and improve the biodiversity and a healthy living environment."

fig. 9 Rietje Klous.

11 Read the text 'Ecology and Environment Adviser'.

a Highlight three measures for nature management in the text.

b Does 'including nature in building' actually create nature? Explain your answer.

c Does 'including nature in building' make biodiversity increase? Explain your answer.

d Give an example of a biotic and an abiotic factor that are influenced by Rietje's work.

e Think of one or more recommendations for a nature-friendly residential area.

Go to the *Flash cards* and the *Test yourself* section.

5 Humans and the environment

LEARNING OBJECTIVES

6.5.10 You can describe several causes and consequences of exhaustion and pollution. ► Experiments 4, 5 and 6

6.5.11 You can describe several causes and consequences of climate change.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES			
	6.5.10	6.5.11	6.2.4*	1.2.4**
Remembering	1abc, 2a	3b		
Understanding	1de, 2bc, 4	3acde, 4		
Using	8a	5, 6ab, 7, 8d, 10acd	10c	
Analysing	8bce	6cd, 9	10be	10b

* You can find this learning objective in another Basics section.

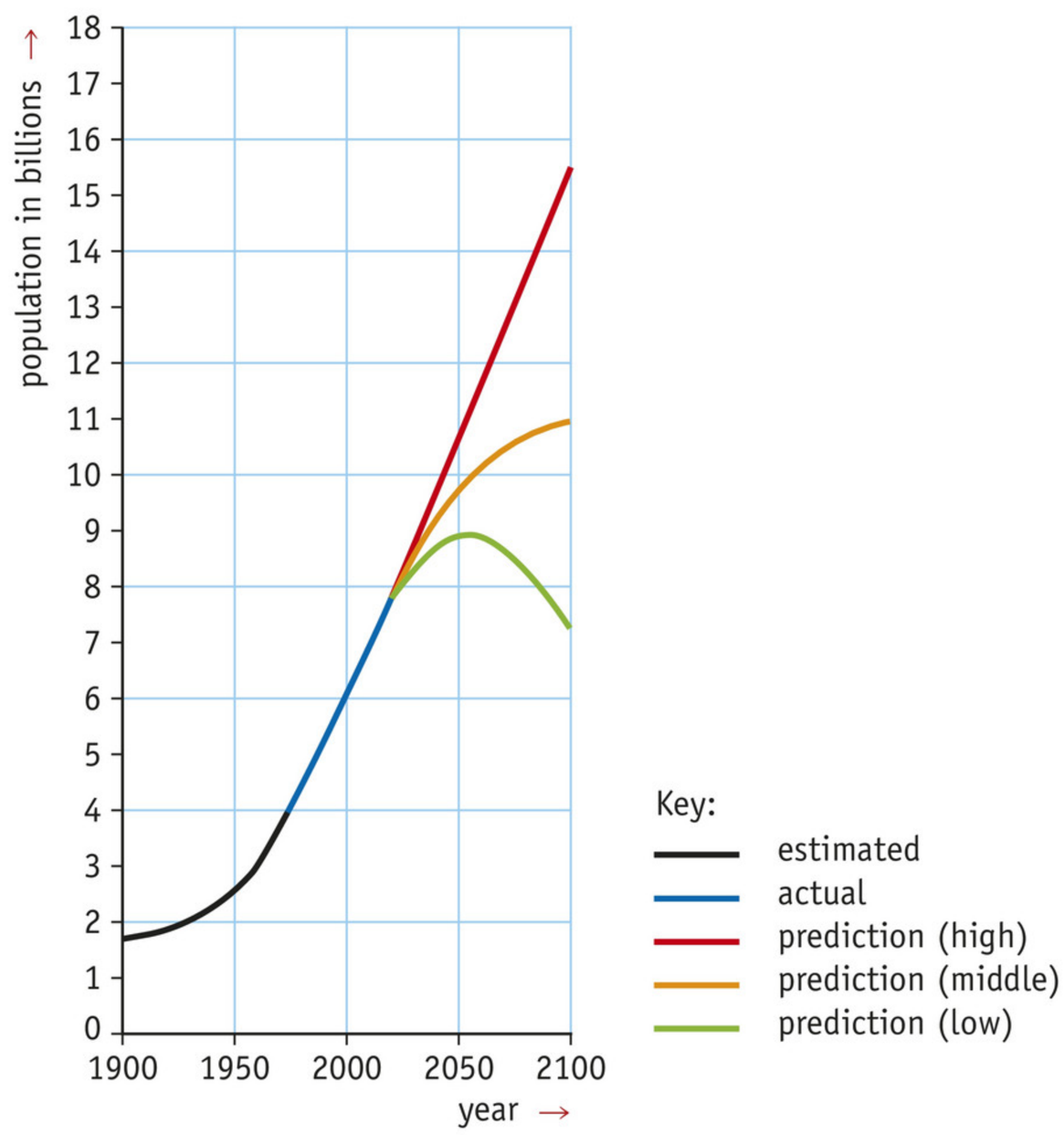
** You can find this learning objective in another unit.

It's not only use of space by humans that has an effect on the living environment of plants and animals. People also take substances from the environment and leave substances behind.

IMPACT ON THE ENVIRONMENT

People have an impact on the environment. Human influence has increased a lot over the past two hundred years. In the last fifty years, the global population has doubled (see figure 1). In June 2019, there were 7.7 billion people. According to the highest predictions there will be 10 billion people in 30 years' time. All these people together use a lot of energy and raw materials and produce a lot of waste (see figure 2).

fig. 1 Growth of the world population since 1900 and the expected growth through to 2100.



Source: United Nations, World Population Prospects 2019.

fig. 2 Waste.

1 household waste

2 discarded appliances

Humans change the environment because we remove certain substances from the environment and add other substances to it. If this causes environmental damage, there are **environmental problems**. The key causes of environmental problems are population growth and people's lifestyles.
Humans cause environmental problems in two ways:

- **Exhaustion**, when we take substances from the environment (such as raw materials).
- **Pollution**, when we add substances to the environment (such as waste products).

EXHAUSTION

Natural gas, petroleum and coal are **fossil fuels**. They were created millions of years ago from the remains of dead plants and animals. These energy resources are getting exhausted. The stocks of natural gas and petroleum are expected to be virtually used up in fifty to a hundred years.
Petroleum is not only a fuel but also a raw material for plastics. A lot of other raw materials also come out of the ground, such as sand (for glass and building materials) and metal ores (for metals). A lot of raw materials are needed for our houses, machinery, devices, clothing and household items. The stocks of these natural **raw materials** become exhausted as a result.

Plants need **minerals** to grow. They absorb the minerals from the ground through their roots. In agriculture, the same plants are grown on large plots of land every year, such as maize (see figure 3). This is called **monoculture**. This causes the soil to become exhausted, meaning that there are not enough minerals in the soil anymore. The plants then no longer grow well. To prevent that, farmers fertilize their land after each harvest. Drought, over-fertilization, erosion and pollution also make soils less fertile. Globally, 23% of the Earth's land area has become less productive as a result.

fig. 3 Monoculture: maize.

POLLUTION

To top up the minerals in the soil, farmers use fertilizers (animal manure or chemical fertilizers). An important mineral in fertilizers is **nitrogen**. Some of the nitrogen from fertilizers ends up in the groundwater and in the air. Industry and traffic (exhaust gases) are important sources of nitrogen in the environment too.
Nitrogen is one of the causes of air pollution. **Air pollution** consists mainly of smog and fine particulates. The nitrogen ends up in nature areas through the groundwater and the air, changing the vegetation there. Stinging nettles and grass grow well with a lot of nitrogen, but some fragile or rare plants cannot tolerate it and disappear.

In the past, waste from chemical industries used to be dumped on landfill sites. This is how toxic substances have ended up in the soil in many places. This is called **soil pollution**. Plants absorb the toxic substances through their roots. This is how toxic substances get into food chains.

Chemical crop protection agents (toxins) protect food crops against damage from insects and pathogens. These substances can get into the water in ditches or end up in the groundwater. This is **water pollution**. This is bad for the quality of the groundwater. Water pollution in rivers, seas and lakes is also caused by households, factories and shipping (see figure 4). Globally, more than 80% of wastewater gets discharged into the environment without treatment. Three to four hundred million tonnes of heavy metals, solvents, toxic sludge and other waste from industrial plants are discharged into the world's waters every year.

Many organisms depend on clean water and soil. Organisms become threatened by pollution or disappear. Clean water and soil are important for human beings as well. We drink water and eat crops that grow in the soil.

fig. 4 Water pollution.

1 wastewater from factories and households

2 pollution from a copper mine

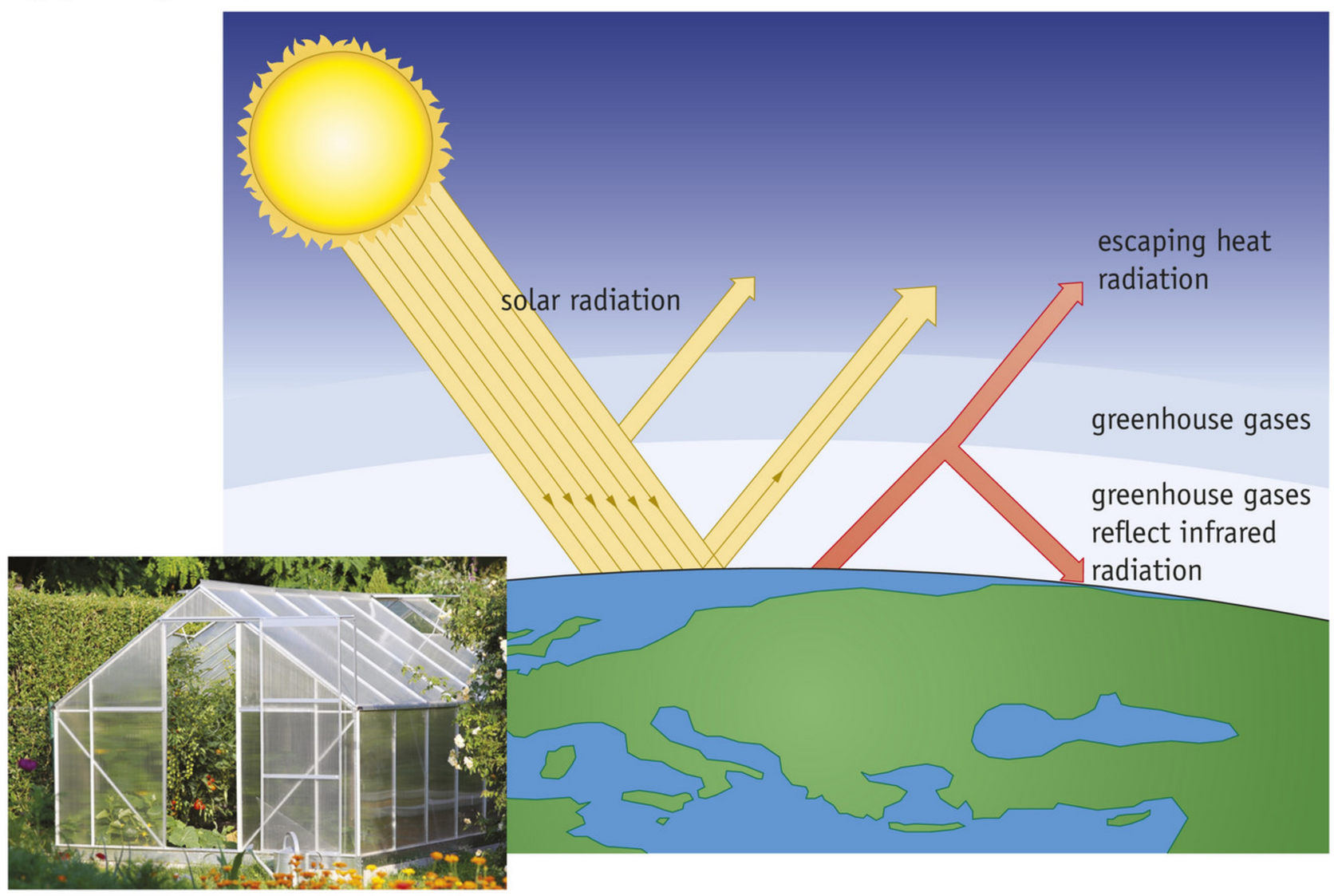
3 dead fish caused by pollution

ENHANCED GREENHOUSE EFFECT

The atmosphere is the layer of air around the Earth. It is a mixture of different gases. These gases allow some of the solar radiation to get through to the Earth's surface. The rest is reflected. Solar radiation warms up the Earth. The Earth also radiates heat away again. Gases in the atmosphere reflect heat radiation from the Earth (see figure 5).

The gases that block heat radiation are called **greenhouse gases** because they have the same effect as the glass panes of a greenhouse. This is called the (natural) **greenhouse effect**. The most important greenhouse gases are water vapour and carbon dioxide. Thanks to the greenhouse effect, the average temperature on Earth is 15 °C. Without the greenhouse effect, the Earth would be a lot colder (–18 °C).

fig. 5 The greenhouse effect.



Carbon dioxide is produced when fossil fuels are burned. People have added a lot of extra carbon dioxide to the atmosphere over the past centuries. Since 1750, the carbon dioxide level in the atmosphere has increased by about 40%. Another important greenhouse gas is methane, which mainly is released by swamps, forests and livestock farming. Levels of methane have also increased since the eighteenth century. The increased amounts of greenhouse gases in the atmosphere reflect more heat back to the Earth. This is the **enhanced greenhouse effect**. The result is that the Earth is getting warmer. Over the past 130 years, the Earth has warmed up by an average of 1 °C. In the Netherlands, the change has been 1.7 °C.

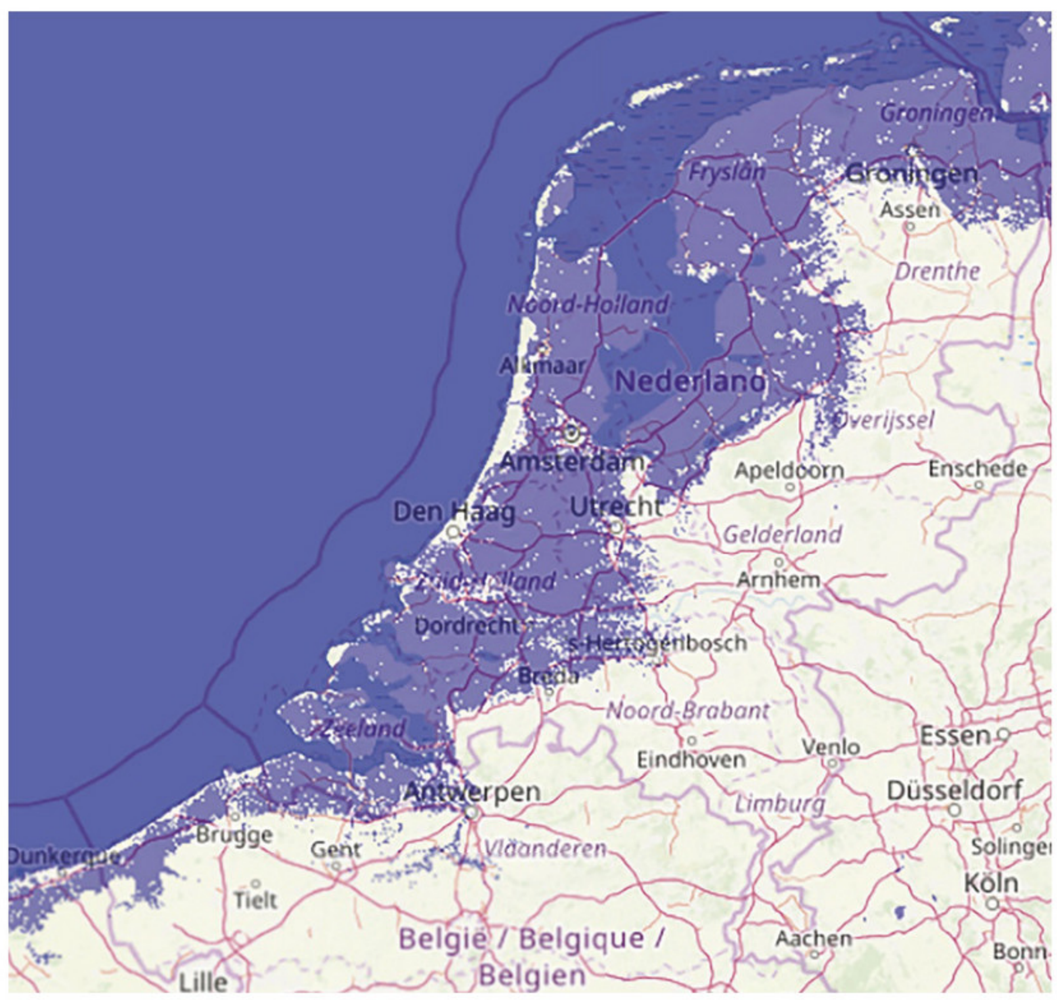
CLIMATE CHANGE

The enhanced greenhouse effect is changing the climate. **Climate change** means that the average weather type changes over a long period. Climate change is giving the Netherlands milder winters, warmer summers and more extreme weather.
The higher temperatures mean that blue-green algae are becoming more common in the waters in summer. **Blue-green algae** (actually a bacterium) produce substances that are toxic to humans. This means that swimming will be prohibited more often (see figure 6).

fig. 6 Swimming prohibited because of blue-green algae.

The Earth getting warmer is causing rising sea levels (the average height of the sea water). Predictions for **sea level rises** for the Netherlands vary from 0.5 to 3 m by the year 2100. Lower-lying areas may get flooded (see figure 7.1). That is why the dykes must be made higher, which is expensive. In other parts of the world, cities and even countries are already being threatened by the higher sea levels. In Oceania for instance, to the east of Australia, entire islands are disappearing into the sea. People who live there will have to move elsewhere (see figure 7.2).

fig. 7 Sea level rises.



1 This much of the Netherlands would flood if the sea level rises by one metre.

2 The people in the photo are standing in the sea where their homes used to be (Kiribati).

In some areas on the planet, higher temperatures lead to droughts, making the deserts get larger. It can lead to shortages of freshwater and drinking water. In the case of extreme droughts, salty seawater can flow back into the rivers. The salt water then mixes with the fresh river water, groundwater and ditch water. This is called **salinification** (from saline = salty). Salinification can cause problems for farmers' crops. Many plants cannot tolerate salt in the water. The salt damages their roots.
Agriculture will become impossible in many areas, but in others the higher temperatures will make crops grow better and provide more food. Parts of the world that are too cold now could also become suitable for agriculture thanks to the higher global temperatures.

HUMAN INFLUENCE

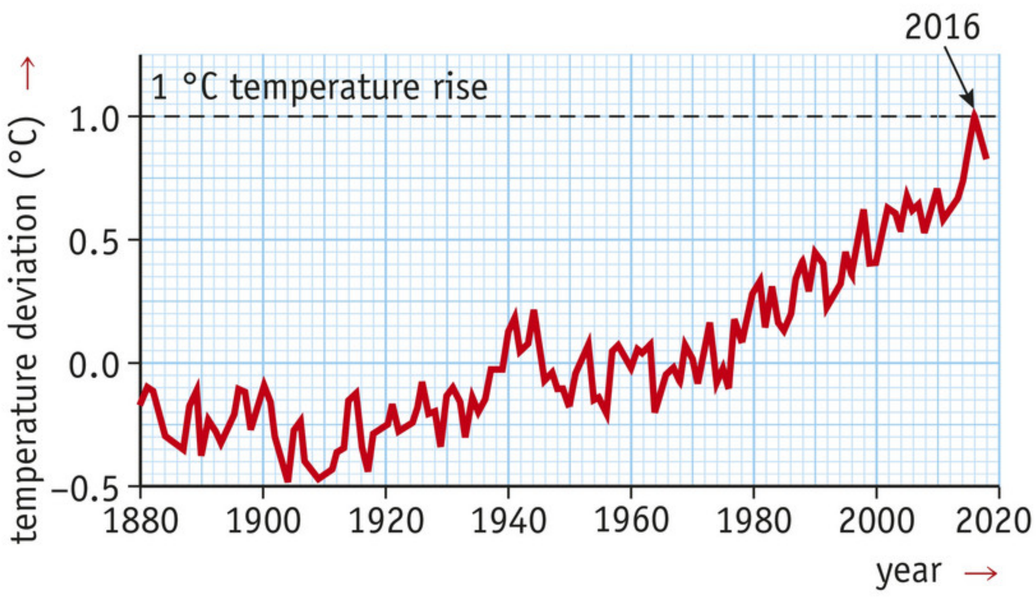
There have been climate changes fairly often in the history of the Earth. But there are three big differences now: climate change is very fast, largely caused by humans and capable of having a major impact on many people. That is why many scientists and politicians are calling this climate change a climate crisis (see figure 8). There are also people who do not believe in climate change, or who think that the consequences will not be so bad. This is often due to a lack of knowledge. The consequences of climate change cannot be predicted exactly, but global warming is a fact (see figure 9).

fig. 8 Demonstration for climate measures.

1 School strike for the climate (London, 2019)

2 Greta Thunberg from Sweden started the school strikes for the climate.

fig. 9 Global warming.



CHANGES IN NATURE

The consequences of climate change are already noticeable in nature. There are plant and animal species in the Netherlands now that used to live only in more southern areas such as in Belgium and France. Other species have become rarer or have disappeared altogether.

Because the winters are less severe and springs have become warmer, the annual rhythm of many species has changed. Trees are getting leaves earlier in the year and many plants are flowering earlier as well. This has serious consequences for some food chains. Great tits like to feed their young with winter moth caterpillars. These caterpillars eat oak leaves. As oaks are getting their leaves earlier in the year, winter moth caterpillars are also appearing earlier. In the period when the great tits' eggs have hatched and their young need to be fed, there are fewer caterpillars left. The great tit has to find other food, such as the oak processionary caterpillar. The breeding season of the great tit is also slowly shifting to earlier in the year.

KNOWLEDGE

1

a
- Taking too many substances out of the environment is a form of .....
- Adding waste products to the environment is a form of .....

b When do environmental problems happen?
c Why have environmental problems increased a lot over the past two hundred years?
d What is chemical crop protection?
e Explain how toxic substances get into the food chain through plants.

2

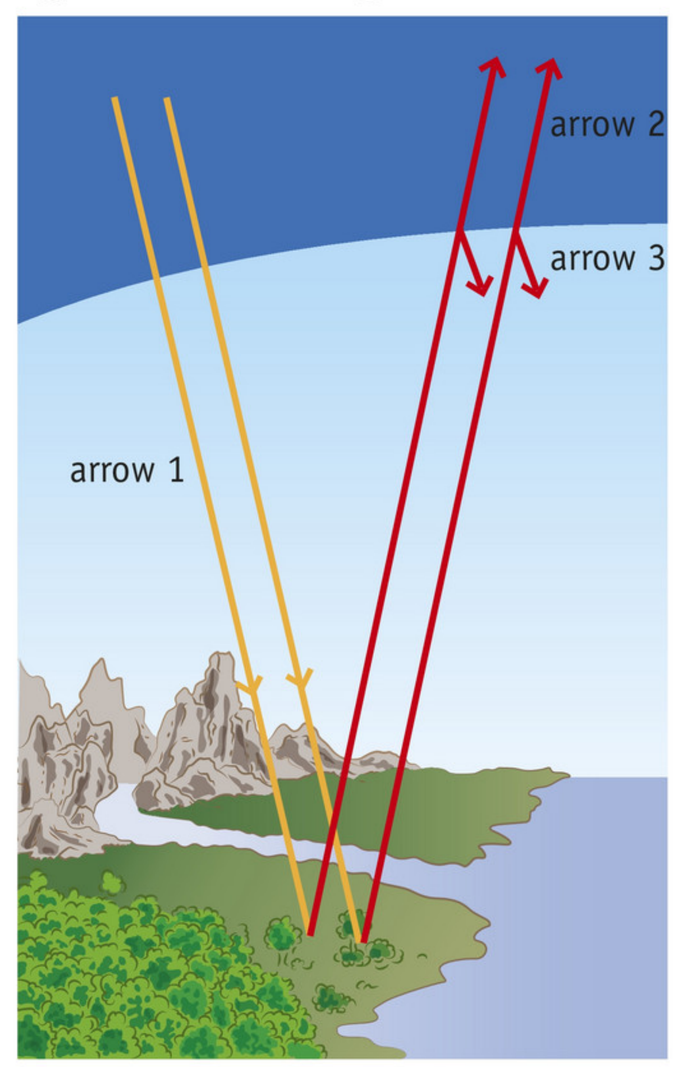
a What is monoculture?
b Which of these are examples of monoculture?
- ☐ A a field where potatoes and wheat are grown alternately
- ☐ B a field where maize has been grown for many years
- ☐ C an apple orchard
- ☐ D a pasture where only perennial ryegrass has been growing for ten years
- ☐ E a pasture where grass and various flowers grow

c Give an example of an environmental problem caused by monocultures.

3

Figure 10 is a schematic drawing of the greenhouse effect.
a Describe what is happening at arrows 1, 2 and 3.
b What are the most important greenhouse gases?
c Explain that without the greenhouse effect there might not be life on Earth.
d What is meant by the 'enhanced greenhouse effect'?
e If the average temperature on Earth rises even more, the amount of water vapour in the atmosphere will increase due to additional evaporation from the oceans.
Will this make the greenhouse effect greater or smaller? Explain your answer.

fig. 10 The natural greenhouse effect.



4

Summary

Make your own summary, for example as a mind map.

INSIGHT

5

Cod – a fish species – live in the North Sea. British biologists have observed that many of this fish's larvae are appearing earlier in the year compared with forty years ago. They suspect that this is caused by the rising temperature of the seawater. Other species, such as some species of plankton, are not appearing earlier or later in the year. The British biologists believe that a difference in timing between cod larvae and their prey is preventing the recovery of the cod population: the cod larvae are dying of starvation.

a Explain why fish larvae can appear earlier in the year due to the rising temperature of the seawater.

b Explain what is meant by "a difference in timing between larvae and their prey".

c Explain what causes this difference in timing.

6

a Explain why using fossil fuels leads to an enhanced greenhouse effect.
b Why do researchers think that increases in levels of industrialization have made the greenhouse effect greater?
c Deforestation means cutting down trees to make fields, houses or industrial areas. Does deforestation add to the enhanced greenhouse effect? Explain your answer.
d Carbon dioxide is produced when biofuels are burned. However, this carbon dioxide does not add to global warming.
Explain why not.

7

Changes due to global warming and the consequences of those changes are listed below.
Connect up each change to the associated consequence.

A	The tick population in the Netherlands is growing.	1	Sea levels are rising.
B	Dry areas are getting even drier.	2	The number of cases of Lyme disease is increasing.
C	Seawater temperatures are rising and glaciers are melting.	3	The number of deaths in the summer is increasing.
D	In Europe, the habitats of plants and animals are extending northwards.	4	New species are appearing in the Netherlands while other species are disappearing.
E	The average temperature in the Netherlands is higher.	5	Food crops are growing better.
F	The Netherlands is experiencing more heatwaves.	6	Birds cannot find enough food to feed their young.
G	Caterpillars are appearing earlier in the year.	7	Deserts are getting bigger.

8

You see more and more electric cars nowadays (see figure 11). These cars run on electricity, which is generated in natural gas or coal-fired power plants or by wind or solar energy.

fig. 11 Electric cars at a recharging point.

a Explain how cars running on electricity can reduce the exhaustion of fossil resources and air pollution.
b Explain why electric cars also cause exhaustion.
c Explain why electric cars also cause pollution.
d Do electric cars add to the enhanced greenhouse effect? Explain your answer.
e You can get around in lots of different ways. Some ways are harmful to the environment, others less so.
Put these modes of transport in the correct sequence. Start with the method that is the least harmful to the environment. Use the Internet to find information if needed.

..... bus

..... car (internal combustion engine)

..... plane

..... bicycle

..... on foot

+ 9 Bacteria in the stomachs of cows produce methane when digesting grass. The amount of methane in the atmosphere is much higher than a hundred years ago.
Explain how greater biodiversity in the vegetation of grasslands can lead to a reduction in methane production.

HOW IT FITS TOGETHER science

GREENHOUSE GAS FROM PEAT BOGS

fig. 12 Peatlands at Vinkeveen.

Peat is made up of dead, partially decomposed remains of plants. Those remains have been compressed into a thick layer in the ground over thousands of years. Peat soil retains a lot of water, making it 'soft'.
Peat bogs in the Netherlands release as much carbon dioxide into the air every year as two million cars. All of this greenhouse gas gets released when the peatland's groundwater table is lowered. This dries the peat out and lets farmers drive over it with their heavy tractors. But peat that has been under groundwater for centuries and is then suddenly exposed to air 'burns' – under the influence of oxygen from the air, bacteria break down the old plant remains, after which the ground sinks and most of the peat is converted into carbon dioxide.
To prevent this, Wageningen University & Research experimented with underwater drainage. A system of pipes in the ground lets water from a ditch flow into the dry land in summer. The meadowland dries out less as a result. As a result, less peat will get oxidized. Peat researcher John Couwenberg from the University of Greifswald in Germany came to a different conclusion: soil subsidence and the release of carbon dioxide that goes with it are not reduced by the drainage. Couwenberg would prefer to make the peat completely wet again: "We would have to do a completely different kind of farming on it. Not grass for livestock, but water plants, for example."

Source: 'Peat bogs spit out as much CO_2 as two million car exhausts', Rob Buiter, Trouw, 6 October 2018.

10 Read the text 'Greenhouse gas from peat bogs'.

a About ten thousand years ago, peat was formed in the Netherlands from the remains of dead plants. In the past, the peat was cut, dried and used as fuel.
Is peat a fossil fuel?

b Peat that is exposed to air 'burns'.
Explain what this means.

c Explain why boggier peat releases less carbon dioxide.

d Who is responsible for the extra carbon dioxide emissions from peat: humans or nature? Explain your answer.

e Explain why peat decomposes faster in the summer.

Go to the *Flash cards* and the *Test yourself* section.

6 Sustainability

LEARNING OBJECTIVES

6.6.12 You can compare the ecological footprint of the Netherlands to that of other countries.
6.6.13 You can explain what sustainability is.
6.6.14 You can state what would be sustainable solutions for environmental problems in the Netherlands.

► Practical activity 7

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES				
	6.6.12	6.6.13	6.6.14	6.1.1*	6.3.6*
Remembering	1a	2ab	3c, 4ac		
Understanding	1bcd, 5	2cde, 5	3ab, 4bde, 5, 8a		
Using	6, 11a	7a	8bcde, 9, 11d	8e	8e
Analysing	10	7bc	10, 11bc		

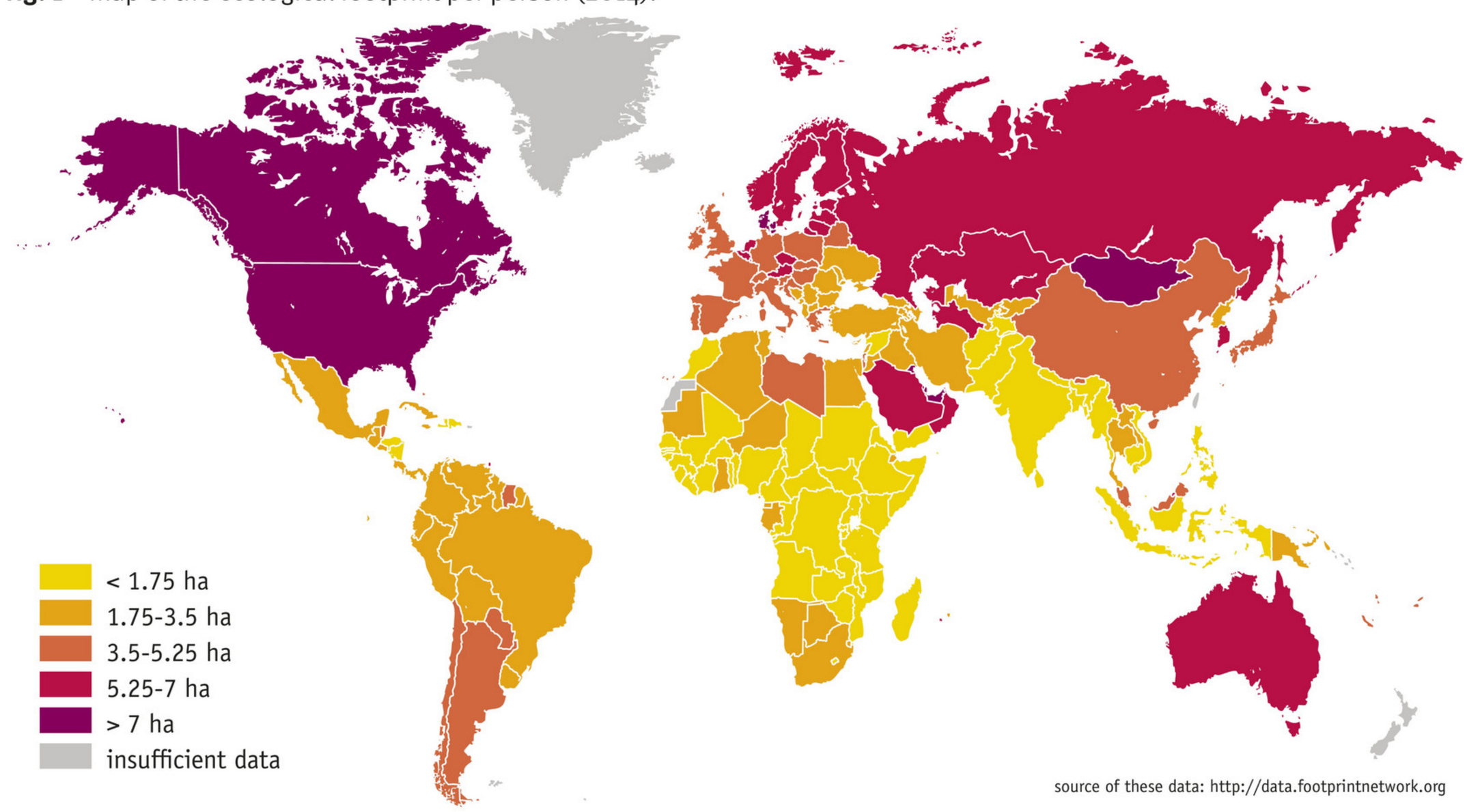
* You can find this learning objective in another Basics section.

People use the Earth for food, raw materials and energy. All of us together use more than the Earth can give. There are sustainable solutions.

ECOLOGICAL FOOTPRINT

Every person uses a piece of the Earth because everyone uses food, energy and raw materials and everyone produces waste. Your **ecological footprint** is the land and water surface area needed for your consumption and waste. The more you consume, the bigger the piece of the Earth you need. The ecological footprint is expressed in hectares (ha). One hectare is a hundred by a hundred metres (100 × 100 m), or about two football pitches. Figure 1 shows the size of the ecological footprint per person in various countries.

fig. 1 Map of the ecological footprint per person (2014).



If we 'divide' the Earth up equally, each person could have 1.7 ha of the planet. The average footprint of people on Earth now is 2.6 ha. That means that we already need one and a half Earths to provide all people with food, energy and raw materials. We only have one Earth, though, so at the moment we are using more than is available. This is exhausting the Earth.
The average footprint of people in the Netherlands is 6.3 ha. If everyone on Earth lived the way we do, we would need more than three Earths.

SUSTAINABILITY

If you are environmentally sustainable, you ensure that the environment is not harmed by your actions. So **sustainability** means:

- not taking more substances from the environment than the environment can replenish
- not adding more substances to the environment than the environment can process

An example of sustainability is making plastics from plant-based materials. Maize stalks and sugar cane can be used to make the building blocks for bioplastics. These raw materials do not get exhausted and the bioplastic is biologically degradable.

To stop global warming, solve environmental problems and not exhaust the Earth further, we need sustainable solutions. According to the United Nations (UN) **sustainable development** is "...development that meets current needs without jeopardizing the ability of future generations to provide for themselves". In other words, using what we need while still passing the Earth on to the next generation in the same state.
There is sustainable energy (also called renewable energy), sustainable agriculture, sustainable housing and sustainable business practices. All these forms of sustainable development use what we need (such as energy and raw materials) but without harming the environment.

Examples of sustainable solutions for environmental problems in the Netherlands are given below.

SOLUTION 1: SUSTAINABLE ENERGY

Sustainable energy is renewable energy that does not cause environmental pollution and does not use up the energy source. Examples of sustainable energy are energy from biofuels (biomass), wind energy, solar energy and geothermal heat. In 2017, 6.6% of the energy generated in the Netherlands came from sustainable sources.

Sustainable energy that is generated in the Netherlands comes mainly from biomass. **Biomass** consists of energy-rich substances (protein, carbohydrates and fats) from biological materials such as wood, organic waste, manure and vegetable oils. Biomass can be used as fuel in power plants. Carbon dioxide is released during its combustion, but the plants absorbed it from the air as they grew in the first place. The amount of carbon dioxide in the air does not therefore increase. Biomass can also be used as a raw material for fuels such as biodiesel and biogas.
But biomass does have drawbacks as well. If crops are specifically grown to be used as biomass, agricultural land is needed. That land can then no longer be used for growing food. Chemical fertilizers are also often used when growing biomass. The plants also need a lot of water.
Wind turbines, solar energy (see figure 2) and geothermal heat ensure that we need less fossil fuel, so that less carbon dioxide and other harmful substances ends up in the environment.

fig. 2 Solar energy.

1 a solar boiler for heating water

2 solar panels for generating electricity

SOLUTION 2: SUSTAINABLE RAW MATERIALS

In the case of **reuse**, an item such as a returnable bottle or second-hand clothing is used again. In the case of **recycling**, waste products are used as raw materials for new products. Paper, glass, metals and clothing are mostly recycled. Cars and electrical devices (such as televisions and computers) are disassembled first. Some parts are reused, others are recycled.
There are also products that are entirely reusable as raw material after the product is discarded. One example is biodegradable trays for chips and fries, which can be used as compost (nutrients) for plants afterwards.

A lot of raw materials and energy are needed to make clothing. 'Fast fashion' is therefore an important source of pollution and environmental exhaustion. Fast fashion means buying a lot of (cheap) clothing, wear it for a short while and then throwing it away. Making clothing also uses a lot of water. One pair of jeans needs about eight thousand litres of water, for instance. The clothing industry also uses a lot of land, petroleum, energy, dyes and other chemicals. Sustainable clothing is made from recycled raw materials or raw materials that do not harm the environment as much, such as Tencel. Table 1 shows how sustainable various fabrics are (the fewer crosses, the more sustainable it is).

Table 1 Comparison of clothing materials (per kilogram of fabric).

Type of cloth (1 kg)	Climate	Land use	Water use	Raw materials	Chemicals
Acrylic	x	x	x	xxx	x
Elastane (Lycra)	x	x	x	xxx	xxx
Hemp	x	xx	x	x	x
Cotton (organic)	x	xxx	xxx	x	x
Cotton (recycled)	x	x	x	x	x
Cotton (new)	x	xx	xxx	x	xxx
Linen	x	xx	x	x	x
Polyamide (nylon)	xx	x	x	xxx	xx
Polyester	x	x	x	xxx	xxx
Polyester (recycled)	x	x	x	xx	x
Tencel (Lyocell)	x	x	x	x	x
Viscose (rayon)	x	xx	x	x	xxx
Wool	xxx	xxx	x	xx	xxx
Silk	xxx	xxx	xxx	xxx	x

Source: MilieuCentraal, De impact van kleding (The impact of clothing), 2019.

As well as using more sustainable raw materials, you can also use *less* of them. Because the fewer people are consuming, the less raw material we need. A few ways to consume less are:

- Having a device repaired when it is broken, instead of buying a new one.
- Buying less clothing and buying second-hand clothing more often.
- Using things for longer before you throw them away or replace them.

SOLUTION 3: SUSTAINABLE AGRICULTURE

There is not currently enough agricultural and horticultural land for producing the large amount of food needed in the future using the current methods. New farming technology can help achieve sustainable solutions. Examples of new methods of food production are urban farming and vertical farming. Precision farming, closed-cycle agriculture and organic farming can help make farming more sustainable.

Urban farming (city farming) involves growing food in an urban environment. Urban farming is often done in buildings or on roofs. If the food is produced in the city, it can immediately be sold in the same city as well. This means that less transport is needed. In **vertical farming**, crops are grown in stacked trays (vertically) using LED light (see figure 3). It therefore needs a lot less land. Using different colours of light can affect the photosynthesis of plants. This can increase the yields.

fig. 3

1 vertical farming

2 precision farming

Precision farming uses technology to give plants very precisely what they need (nutrients, light, water). To achieve this, a farmer uses GPS, robots, sensors, drones and computers. The farmer does not determine what he has to do for each field but instead for each square metre and sometimes even for each plant. This can save a lot of energy and raw materials, while the crops' yield remains the same or can even increase.

In **closed-cycle agriculture**, the focus is not on producing as much food as possible but on handling natural resources such as soil, air and water sustainably. All biomass (vegetable and animal) is used in the best way possible. Waste is reused as raw material. Example: food we no longer eat is used as feed for animals. In closed-cycle agriculture, farmers make clever use of natural processes (ecology), use raw materials sparingly and make sure they harm the environment and nature as little as possible.

Organic farming grows food in a different way to regular agriculture. Organic farming does not use artificial fertilizers (only animal manure instead) and no more than the plants can absorb. Organic farming does not grow monocultures and does not use chemical crop protection agents. Weeds are removed mechanically (by hand or by machinery). One disadvantage of organic farming is that the yields are often lower. As a result, more land is needed to produce the same amount of food. Production costs are also higher, making organic food more expensive.

SOLUTION 4: LESS POLLUTION

The Dutch government and the countries of the European Union collectively make rules that people, industry and agriculture have to respect. There are all kinds of measures to prevent environmental pollution. Ships and factories are not allowed to discharge harmful substances into the environment. Instead they must collect them and process them properly. In the Netherlands, wastewater is purified before it is discharged into surface waters. Cars are fitted with catalytic converters that make exhaust gases less polluting. Factories have filters in their chimneys and farmers filter the air coming out of the stables. Many other parts of the world do not have these rules and agreements. There is still a lot of pollution there.

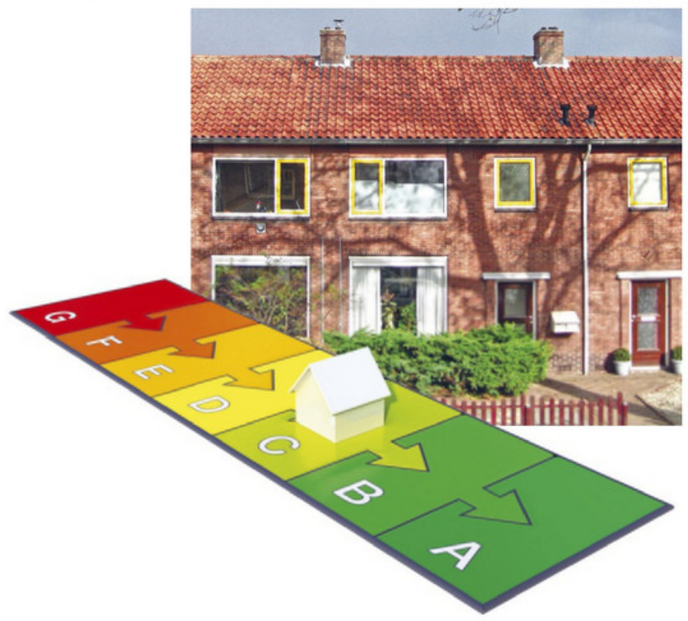
But even in the Netherlands, we can still reduce environmental pollution further. Measures against air pollution include:

- driving fewer mopeds and cars, using public transport or cycling more often
- not setting off fireworks on New Year's Eve
- not burning wood in a wood burner, brazier or fireplace

SOLUTION 5: LESS GREENHOUSE GASES

If the amount of carbon dioxide released into the air is to be reduced, it is important that we use less energy. Our use of fossil fuels in particular causes carbon dioxide emissions. Using less fossil fuel lets us reduce emissions.
Measures that help include insulating buildings and using energy-efficient appliances. Energy labels tell you how energy-efficient a house, device or car is (see figure 4).
Adaptions to livestock farming can also help reduce greenhouse gases. Methane is produced in the stomachs of ruminants such as cows and sheep. An average cow produces 90 kilograms of methane every year – as much greenhouse effect as 120 L of petrol. Methods for reducing methane production are now being studied.

fig. 4 Energy labels.



1 energy label for a house

2 energy label for a car

MAKING SUSTAINABLE CHOICES

What can you do to cut your energy consumption? For example, do you switch off the light when you leave your room? Or do you ever buy things in second-hand shops? Things you can do yourself include:

- throwing waste in a bin and not on the streets
- turning down the heat a notch
- not using plastic bags and packaging
- taking shorter showers (saves water and gas/electricity)
- paying attention to labels on products, such as notebooks (environmentally friendly paper)
- buying less new clothing, wearing clothing for longer
- travelling by train instead of by plane
- using a bicycle more often instead of a car or moped

fig. 5 Ten reliable labels.

KNOWLEDGE

1

a What does your ecological footprint mean?
b How many square metres of the Earth's surface are available for each person?
c How many square metres do Dutch people use on average at the moment?
d The average footprint of people in Qatar is 11.8 ha.
How many Earths would we need to provide everyone with food, energy and stuff if we all lived like the people in Qatar do?

..... Earths

2

a What is sustainability?
b Why are bioplastics sustainable? Give two reasons.
c Why is energy from biomass sustainable? Give two reasons.
d Why is solar energy a sustainable energy source? Give two reasons.
e What does 'sustainable development for the generations after us' mean?

3

a What is the purpose of recycling?
b How will this goal be achieved?
c What could you do to reduce the amount of raw materials being used? Write down at least three ways.

4

a What is urban farming?
b What is one advantage of urban farming?
c What is vertical farming?
d What is one advantage or vertical farming?
e Wasted energy and wasted raw materials are avoided in both precision farming and closed-cycle agriculture but it is done is differently.
Describe the difference.

5

Summary

Sustainable development: .....

.....

Ecological footprint: .....

.....

.....

.....

.....

	Sustainable solutions
Greenhouse gases	
Energy	
Raw materials	
Agriculture	
Pollution	

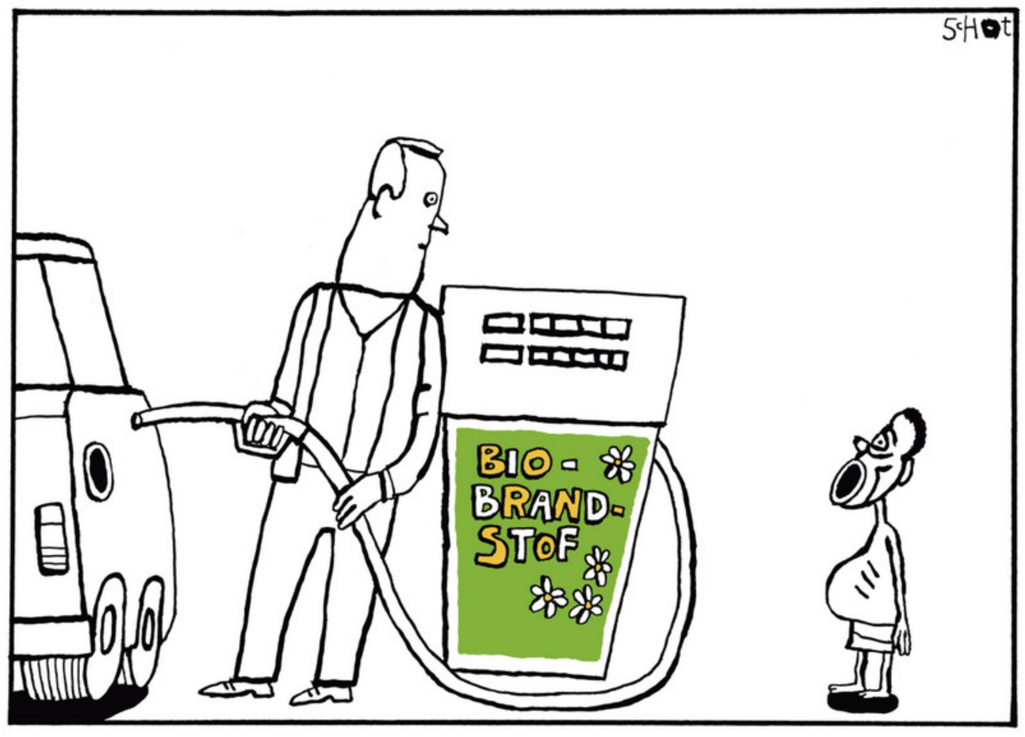
INSIGHT

6 Germany is similar to the Netherlands economically. They earn about as much money there and people have the same standard of living. Despite that, the ecological footprint of Germany is quite a bit smaller, at 4.6 ha.
Why would the footprint of Germans be smaller than that of Dutch people?

7
a The Swiss brand Freitag turns used truck tarpaulins, seat belts, bicycle tyres and airbags into bags and accessories.
Explain why producing Freitag bags is an example of sustainable development.
b Life Materials is the company that makes 'MuSkin'. MuSkin is a material for clothing that is comparable to leather (which is made from animal skins) or fake leather (made from plastics). However, MuSkin ('mushroom skin') is based on fungi.
Explain why the production of MuSkin is more sustainable than that of synthetic leather.
c Leather is made from animal skins, another natural material.
Explain why the production of leather from cowhide is less sustainable than the production of MuSkin.

8
a Figure 6 shows a cartoon about the use of biofuel.
Explain what the cartoonist is trying to say.
b Some biofuels are made from waste wood, agricultural waste (such as straw and chaff, the hard protective layers around cereal grains) or old frying fat.
What is the advantage of these biofuels?
c Some biofuels are made from algae (single-celled plants). The algae are grown specifically for producing biofuels.
What is one advantage of biofuel from algae?
d Palm oil is used as a vegetable oil in foods and other products. Palm oil is also very suitable for making biodiesel. On Borneo, rainforest is being cleared to set up palm oil plantations so that more palm oil can be produced. The forested area decreased by 498,000 ha a year on average over the period 2000 to 2010.
How many football pitches of forest were destroyed every hour in Borneo to make way for palm oil plantations? Assume a football pitch is 100 m × 50 m.
e in 1995, there were 12,000 orang-utans living in the protected nature reserve of Sebangau on Borneo, but now there are only between 7000 and 9000.
Explain how the decline in the number of orang-utans could be the result of the construction of palm oil plantations.

fig. 6 Biofuel.



9 What things can you do yourself to live more sustainably? You can write down your own solutions in 9 and 10.

Sustainable solution	I already do this	I want to try this
1 Throwing waste in a bin and not on the streets		
2 Turning down the heat a notch		
3 Not using plastic bags and packaging		
4 Taking shorter showers (saves water and gas or electricity)		
5 Paying attention to labels on products, such as notebooks (environmentally friendly paper)		
6 Buying less new clothing, wearing clothing for longer		
7 Travelling by train instead of by plane		
8 Using a bicycle more often instead of a car or moped		
9		
10		

+ 10 In the future, we will probably need a lot more food because there will be many more people on Earth. There is not currently enough agricultural land for producing this large amount of food using current methods.
Explain why taking up more land for food production is not a sustainable solution to that problem.

HOW IT FITS TOGETHER the living world

FRESH VERTICAL FOOD

Vertical farming is a new form of agriculture, achieving higher yields with a smaller ecological footprint. In vertical agriculture, the grower can adjust the lighting, temperature, climate and food for the plants very precisely. This makes it possible to see just what the right 'recipe for growth' is for each crop. This means there is little wastage.
Growers can also determine the crop's features. Adjusting the 'recipe' lets them increase or decrease certain substances in the crops. One example is the nitrogen content in lettuce, but the levels of nutrients and vitamins can also be influenced.
Vertical farming is done in or near cities. This lets growers grow exactly what they need and respond to market demand. It reduces the amount of wasted resources and waste produced, and crops get to the customer faster (and so they are fresher too).
Vertical farming is sustainable, and not only because there is less wastage. The plants are in controlled closed spaces, reducing the risk of disease. This means pesticides are not needed. Finally, cultivation in a closed system like this needs over 90% less water than traditional agriculture or horticulture. This allows crops to be grown in dry areas.

Source: https://duurzaambedrijfsleven.nl, 'City Farming: fresh food in a shorter chain', Chris Thijssen, 15 November 2015.

fig. 7 Basil plants being grown under coloured LED lighting.

11 Read the text 'Fresh vertical food'.

a What measures in the text reduce the ecological footprint? Write down at least three.

b Explain why vertical agriculture needs less water than regular agriculture.

c The closed, controlled spaces reduce the risk of disease.
What could be another reason why less pesticides are needed?

d How can vertical agriculture be a solution for the food question in dry areas?

Go to the *Flash cards* and the *Test yourself* section.

How it fits together

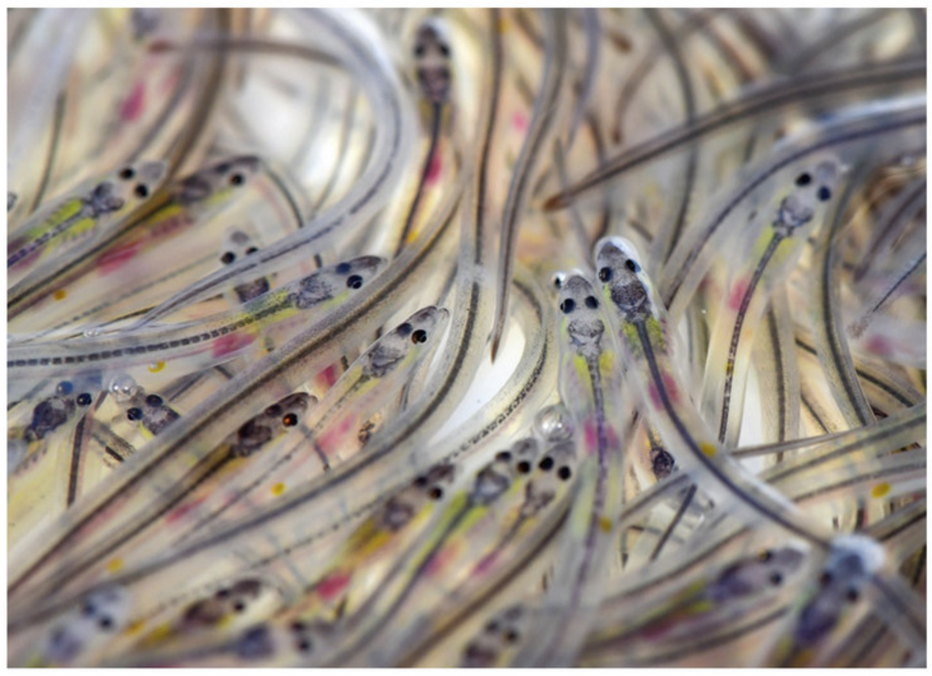
ELVER SMUGGLERS CAUGHT

In April 2018, customs officers at Schiphol Airport made a remarkable find in someone's luggage. In the suitcases of two Chinese people, they found 36 bags of wriggling baby eels. The Chinese couple were sentenced to six months in prison for smuggling and animal cruelty.

ENVIRONMENTAL CRIME

By smuggling the baby eels (elvers), the Asians were taking part in the biggest environmental crime in Europe. Every year, almost a quarter of all baby European eels (*Anguilla anguilla*) are smuggled to Asia. The goal: to raise the elvers into adults of more than a metre long and then sell them to restaurants. Eels, which are oily fish that are rich in flavour, are a delicacy in Japan in particular. Two slices of eel can cost you the equivalent of €40. There are fewer and fewer Japanese eels (*Anguilla japonica*) because of the enormous levels of consumption, which is why restaurants are trying to find other ways of obtaining eels. European eels are so much like the Japanese eel in both look and taste that few people notice the difference. That is why smuggling elvers to Asia brings in more money than the ivory trade. In Japan, a kilogram of glass eels can cost as much as 33,000 euros.

fig. 1 Elvers.



Why do they not just breed their own eels in Asia? The answer is simple: no one has ever succeeded in doing that. In nature, European eels mate in the Sargasso Sea, at latitude 22°30' N, longitude 48°65' W. The larvae that come out of the fertilized eggs go on an immense 6000 km journey to Europe. When they get near the coast, the leaf-shaped larvae develop into transparent elvers ('glass eels'). Once the elvers are in fresh water, they grow and become golden coloured ('yellow eels'). It takes ten years or more for the eels to mature. They then turn silver in colour, their eyes grow larger and they prepare for the journey to the Sargasso Sea, where they reproduce. During their journey back to the Sargasso Sea, the eels do not eat and their reproductive organs develop while they are underway.

HORMONES

After a lot of experiments, scientists have managed to get eels to mate in captivity. They used alternating fresh and salt water. They also added hormones to the water. The eels laid eggs that hatched, but the scientists have not yet managed to keep the larvae alive for more than a week. The problem: we simply don't know exactly what eel larvae eat.

WATER MANAGEMENT

Because eels are in great demand in Asia, poachers catch elvers and sell them to smugglers. This is closing the net around the European eel even more tightly. The eel is in fact seriously endangered, even more so than the giant panda. The number of elvers in Europe is only about 10% of what it was half a century ago. A combination of factors is causing this: water polluted by harmful chemical substances and heavy metals, changing sea currents, increased fishery, loss of habitat, blood-sucking roundworms and water management measures in the Netherlands are probably all playing a role. Pumping stations, dams and dykes prevent elvers from swimming upstream and older fish from swimming back downstream. The eels get stuck or get crushed by the pumps.

To control eel smuggling better, Operation LAKE was launched. It is a large campaign to prevent the smuggling of wildlife. Interpol (the international police force) and Europol (the European police) and others are all taking part in it. Maybe the eel still has a chance.

Source: "The mafia now smuggle baby eels: just as lucrative as cocaine, but with a near-zero chance of being caught," Marcus Pfeil, De Correspondent, 18 August 2018, and Max Wastiaux, project employee at the Good Fish Foundation (GFF).

EXERCISES

1

a What five stages are there in the lifecycle of an eel?

b Why is it not surprising that eel larvae do not eat the same as yellow eels?

c In the Netherlands, eels eat mosquito larvae, small perch (fishes), mussels and amphipods.
What position do eels have in the IJsselmeer food web?

d On the way to the Sargasso Sea, the adult eels do not eat.
What position do the eels then have in a food chain?

2

The decreased number of eels has various causes.

a What factors are caused or driven by humans?

- ☐ A blood-sucking roundworms
- ☐ B increased fishery
- ☐ C changing sea currents
- ☐ D loss of habitat
- ☐ E water pollution by chemicals

b Which of these factors are biotic factors?

- ☐ A bloodsucking roundworms
- ☐ B increased fishery
- ☐ C changing sea currents
- ☐ D loss of habitat
- ☐ E water pollution by chemicals

c Explain how some Dutch water management measures make it difficult for the number of eels to increase.

d Is the European eel population in biological equilibrium? Explain your answer.

3

a An eel is an oily fish.
Is the biomass of an eel equal to its fat content? Explain your answer.

b Explain why eating eels can bring more health risks than eating white fish such as coley.

c Eels sold in Japan may originate from glass eels smuggled out of Europe.
How would inspectors be able to tell whether eel in a Japanese restaurant comes from European glass eels?

d Fish in the supermarket is sometimes labelled 'ASC' or 'MSC'. MSC is a label for sustainable fish caught in the wild. ASC is a label for sustainably farmed fish. However, there are no eels with ASC or MSC labels yet.
Why is that?

4

a Do wild eels mate in the Netherlands?

b What factors that stimulate the development of reproductive organs are missing in European waters? *abiotic* / *biotic* factors

c Might it be possible to make the reproductive organs grow in eels in the Netherlands through 'gene editing'?

5

a What form of nature management could be done in the Netherlands to allow the number of eels to increase?

b Why is it not enough if only the Netherlands implements good management?

c Is reintroducing the eel into Dutch waters a possibility for increasing the number of eels again? Explain your answer.

d The decline of the eel population is a problem at the level of *the biosphere* / *a biotope* / *an ecosystem* / *a community* / *a population* / *the individual*.

6

a A pupil says, "The best way to save the eel is to study how we can make them reproduce in captivity."
Do you agree? Explain your answer.

b Another pupil says, "Catching and selling eels should be banned in the Netherlands."
Do you agree? Explain your answer.

7 The energy flow in an ecosystem

LEARNING OBJECTIVE

6.7.15 You can describe the energy flow in an ecosystem.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES	
	6.7.15	6.1.3*
Remembering		
Understanding	1, 2abc, 3, 4a	
Using	2d, 4b	2d
Analysing	4c, 5	

* You can find this learning objective in another Basics section.

Photosynthesis takes place in plants because they have chlorophyll. In photosynthesis, an energy-rich compound (glucose) is made from carbon dioxide and water.

AUTOTROPHIC AND HETEROTROPHIC

Glucose is a raw material for making all the substances that a plant consists of. To be able to make those substances, plants absorb minerals from the soil. So plants do not feed on other organisms. They obtain the substances they need to live from non-living nature. If an organism does not need any other organisms as food, it is called **autotrophic** (*autos* = self, *trophein* = to feed).

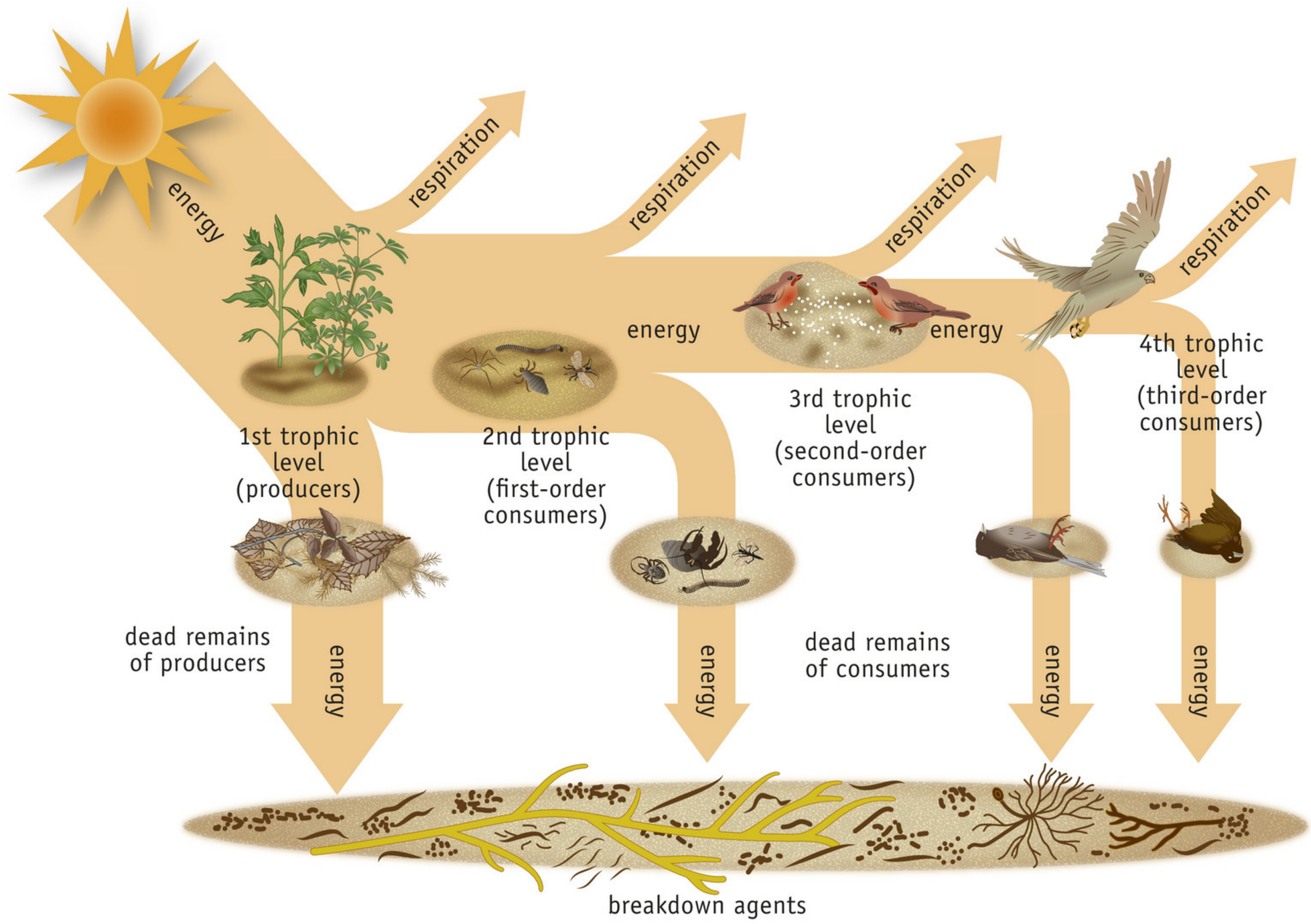
Organisms without chlorophyll cannot stay alive from just the substances from non-living nature. Substances from non-living nature have very little energy. Organisms without chlorophyll cannot create energy-rich substances themselves from substances that are low in energy. They need to take in energy-rich substances as part of their food. So they have to feed on other organisms or parts of other organisms.
Animals, fungi and most bacteria do not have chlorophyll. These organisms feed on other organisms. These organisms are called **heterotrophic** (*heteros* = other, *trophein* = to feed).

ENERGY FLOW

The place of an organism in a food chain is called its **trophic level**. Producers are autotrophs and they make up the first trophic level; primary consumers are the second trophic level, secondary consumers are the third trophic level, and so forth. The biomass decreases in each trophic level. This is because the energy in the food is being used up in various ways.

In ecosystems, the energy from one trophic level is passed up to the next trophic level, so there is an **energy flow** (see figure 1). Plants capture energy from sunlight by photosynthesis in glucose. In the combustion (respiration) of glucose, that energy is released. That is why glucose is an **energy-rich compound**.
Glucose is turned into other substances in plants. Because the energy from the glucose is now in these other substances, they are now also energy-rich compounds. Examples of such substances are DNA, proteins, carbohydrates and fats. They are the building materials that all organisms consist of.

fig. 1 The energy flow in an ecosystem.



Producing these building materials takes energy. To do that, the plant combusts some of the glucose (cellular respiration). Other processes, such as transporting substances, also need energy. Because of that combustion, some of the energy is not made available in the next trophic level but is lost as heat.

A proportion of the biomass of the producers gets eaten by consumers. The energy in those producers is passed up to the next trophic level this way. The consumers use some of the energy-rich compounds to grow. This increases their biomass. The rest of the energy-rich compounds is burned as fuel (combusted). This releases energy for moving, for instance.

Each link in a food chain produces waste from organisms and some individuals die without getting eaten. The energy-rich compounds from these dead remains disappear from the food chain. The energy in these energy-rich compounds is used by breakdown agents. In the end, all the energy-rich compounds get combusted. Water and carbon dioxide become available to plants, which can then capture energy from sunlight again.

EXERCISES

1

a When do we say that an organism is an autotroph?

b And when do we say that an organism is a heterotroph?

c
- Do autotrophic organisms absorb low-energy substances from their environment? *yes / no*
- Do autotrophic organisms absorb energy-rich substances fro their environment? *yes / no*

d
- Do heterotrophic organisms absorb low-energy substances from their environment? *yes / no*
- Do heterotrophic organisms absorb energy-rich substances from their environment? *yes / no*

2 Organisms are divided into kingdoms, including the bacteria, animals, plants and fungi.

a Which kingdom contains autotrophic organisms?
the bacterial kingdom / the animal kingdom / the plant kingdom / the fungal kingdom

b In which kingdoms are the organisms heterotrophs?
the bacterial kingdom / the animal kingdom / the plant kingdom / the fungal kingdom

c Answer the questions in the table.

	Autotrophs	Heterotrophs
Do the organisms have chlorophyll?	*yes / no*	*yes / no*
Does photosynthesis take place in the organisms?	*yes / no*	*yes / no*
Does respiration take place in the organisms?	*yes / no*	*yes / no*

d Why can't a food chain ever start with an animal species?

3 A cow gets energy-rich substances when it eats grass. The pie chart in figure 2 shows what happens to these energy-rich substances.

a What percentage of these energy-rich substances is not actually used by the cow at all?

.....%

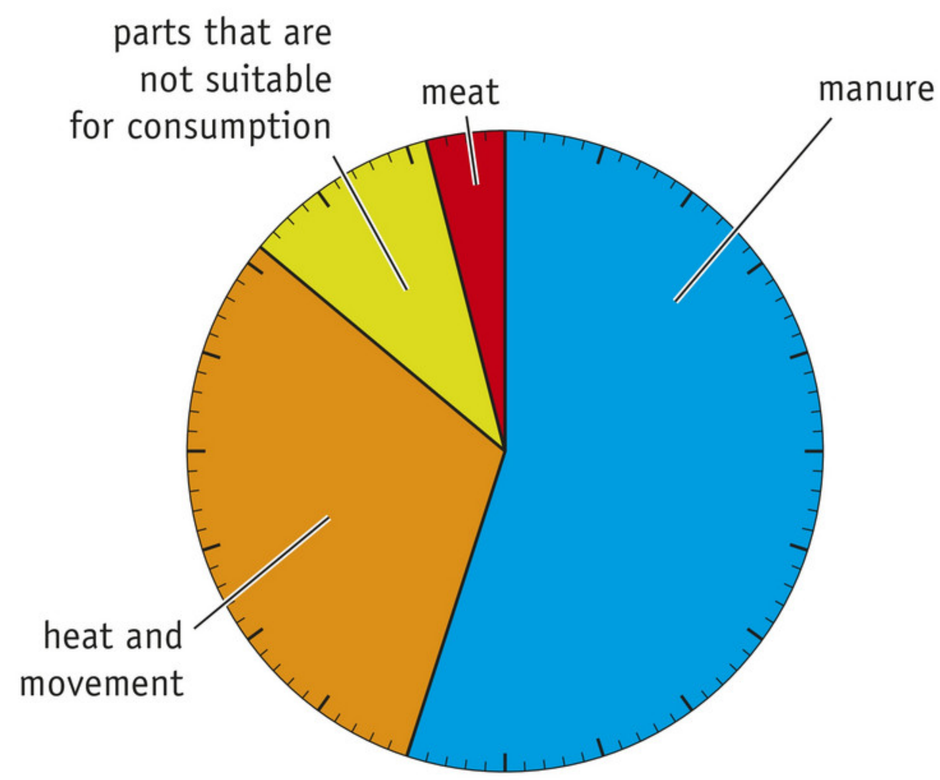
b What percentage is used as fuel?

.....%

c What percentage is passed on to humans?

.....%

fig. 2



4

a In which trophic level (or levels) can photosynthesis take place? Explain your answer.

b In an ecosystem, there is less energy for organisms on the third trophic level than for organisms on the second trophic level.
Explain why.

c Breakdown agents release energy by breaking down energy-rich compounds in the dead remains of producers and consumers.
What energy-rich compounds (at least) are broken down by breakdown agents?

+ 5 Producing 1 kg of beef requires about 30 kg of feed. The production of 1 kg of edible insect products requires only about 3 kg.
Why do insects need less energy-rich compounds to grow heavier than cattle do?

Go to the *Flash cards*.

8 Food production

LEARNING OBJECTIVE

6.8.16 You can describe the agriculture in the Netherlands.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES		
	6.8.16	6.1.3*	6.5.10*
Remembering			
Understanding	2a, 4a, 5a, 6a, 7		2a
Using	1a, 3c, 4b, 5bc, 6bc	1b	1a
Analysing	2bc, 3ab, 6d		2b

* You can find this learning objective in another Basics section.

Researchers have calculated that there will be over nine billion people on the Earth by 2050. Twice as much food will have to be produced in order to feed all these people.

AGRICULTURE

Agriculture includes all activities that change the natural environment, making it suitable for producing food. There are three types of agriculture:

- arable farming (large fields with potatoes, sugar beets, corn)
- livestock farming (meadows and stalls with cows, pigs, chickens, sheep, goats)
- horticulture (greenhouses and small fields with vegetables and fruit)

fig. 1 Three types of agriculture.

1 arable farming

2 livestock farming

3 horticulture

Plants that are grown in arable farming and horticulture are called **food crops**. Animals that are kept for livestock farming are called **farm animals**. People have been trying for centuries to maximize the yields of food crops and farm animals. For food crops, this can be done by fertilizing and processing the soil and by protecting the crops against diseases and pests. For farm animals, it can be done through special feed for the animals and by protecting them against disease. Yields can also be improved by breeding and cross-breeding or by using modern techniques from biotechnology.

ARABLE FARMING

Arable farms are often large farms with a lot of land. Most of the time, only a single type of crop is grown on those large fields (monoculture), for example potatoes, wheat or sugar beets.

Monocultures have great advantages for the farmers. They can use larger machines for working the soil and for harvesting. This is fast and easy. Crops can be grown more cheaply as monocultures.
But monocultures have disadvantages too. In monocultures, there is a lot of food for insects. There is therefore a higher risk of insect plagues. The plants in a monoculture also grow very close to each other. As a result, pathogens can spread easily among the plants.
Monocultures make the soil become exhausted quickly. Fertilizers are then added to put the minerals back into the soil. There are two types of fertilizers: organic fertilizers and chemical fertilizers. **Organic fertilizers** come from organisms. Injecting manure into the soil as a liquid means less fertilizer gets into the environment (see figure 2). **Chemical fertilizers** are made artificially in laboratories or factories. Chemical fertilizers give a farmer more control over the types and quantities of minerals to be added to the soil.

fig. 2 Manure injection into grassland.

CROP PROTECTION

In agriculture, food crops are protected against disease either by chemical crop protection agents or by using biological methods.
There are many chemical crop protection agents (pesticides) that are used to fight plant disease and pests. Chemical crop protection agents are **biocides**. This means that they kill living organisms. The good thing about them is that they work very quickly. These agents can usually fight diseases and pests effectively.

But chemical crop protection agents (pesticides) do have a lot of drawbacks. They kill not only the harmful species but often harmless and even useful ones too. These agents are called **non-selective pesticides**. Developing selective biocides is complicated and therefore also expensive.

Another disadvantage is that the species that is being tackled often develops resistance to the crop protection agent within a short time. Different genotypes are produced by sexual reproduction. Species that are being tackled often turn out to contain individuals with genotypes that make them insensitive or less sensitive to the pesticide used. These organisms are **resistant**.

These resistant organisms in particular will survive and reproduce (see figure 3). As a result, the entire species can become resistant to the crop protection agent after several generations. This will lead to a new plague. Larger quantities or different crop protection agents will then be needed for fighting this plague.

A third disadvantage of chemical pesticides is that they can end up in the food chain, where they accumulate (the concentration of toxins gets greater in organisms higher up the food chain).

fig. 3 The development of resistance to a chemical pesticide.

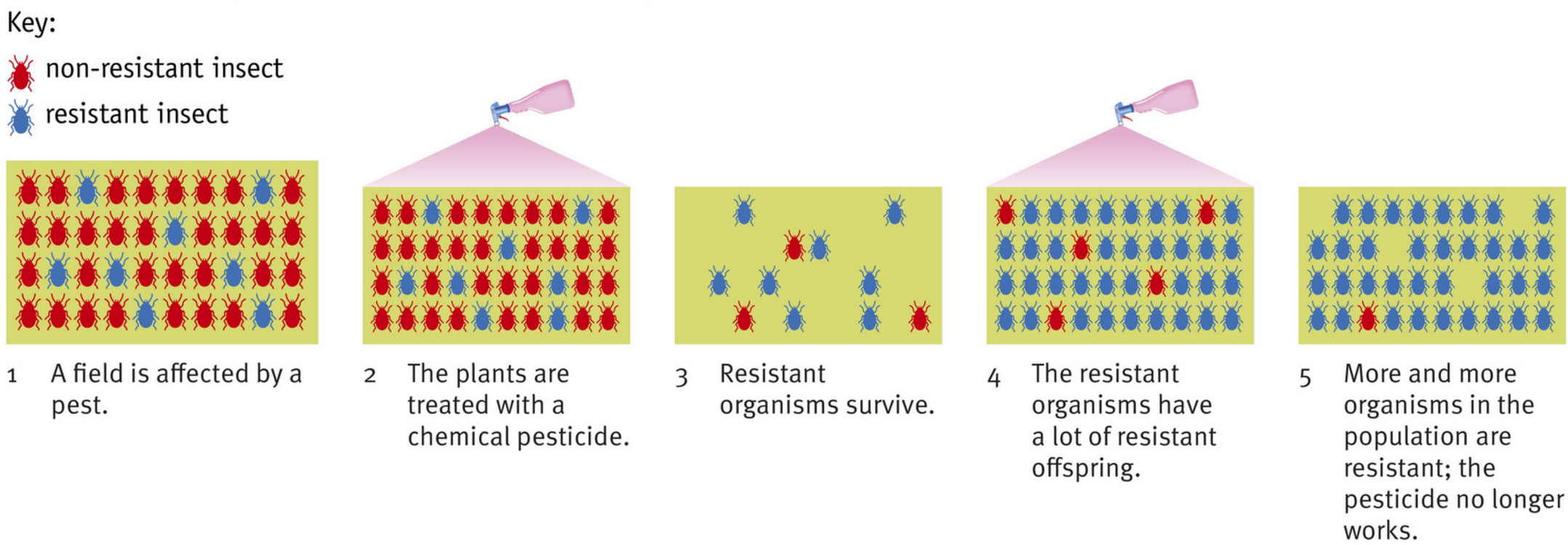
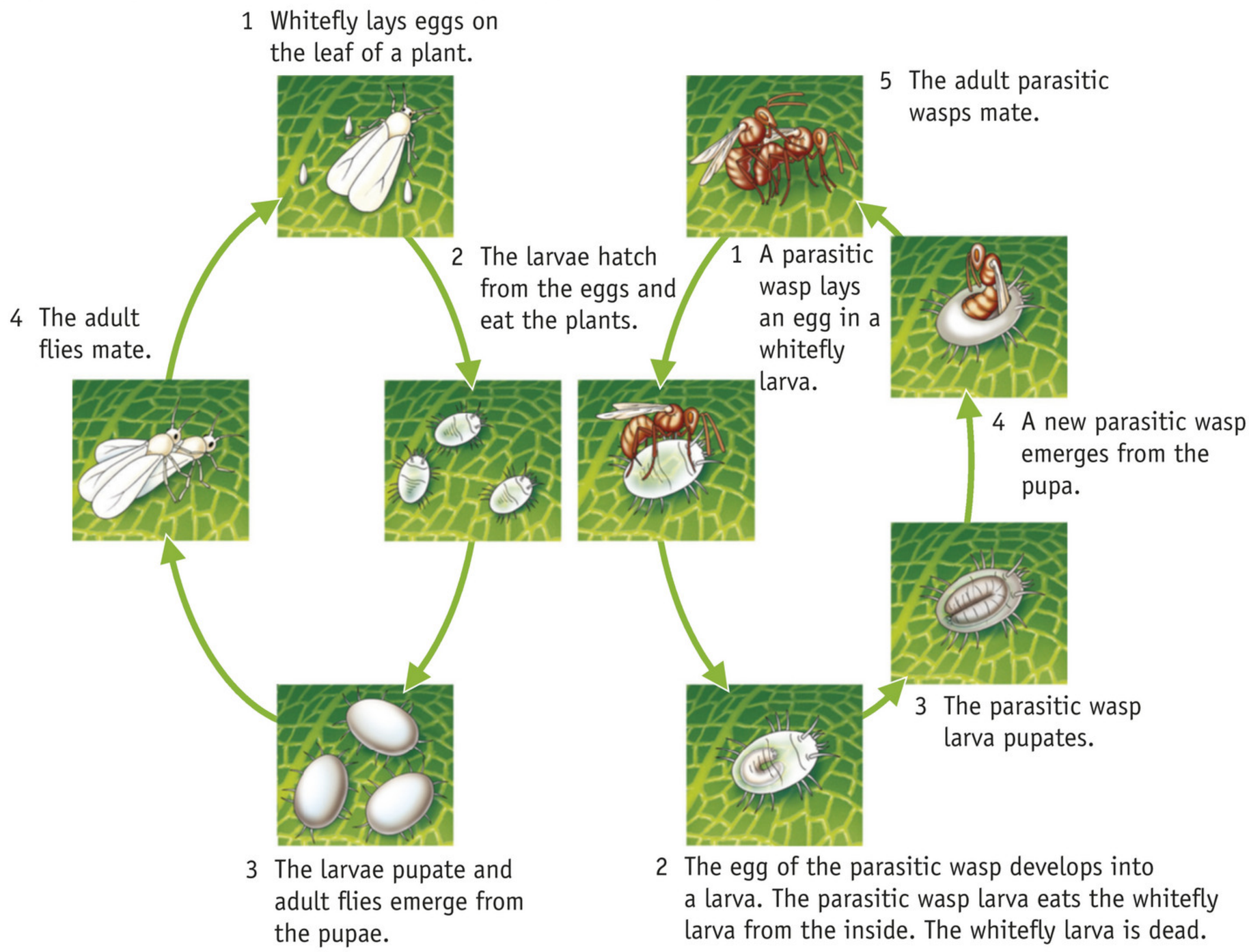


fig. 4 Biological protection against whitefly using parasitic wasps.



Organic crop protection makes use of biological phenomena. No chemical crop protection agents are used, but they do use natural toxins. Some insect species can be tackled by animals that are their enemies in nature. These are the **natural enemies**. The use of natural enemies is also referred to as biological or **organic crop protection**. An example of this approach is tackling whitefly using parasitic wasps (see figure 4).

ORGANIC FARMING

Organic farming tries to protect the environment while still producing enough food. Monocultures are avoided, for example, and crops are varied on smaller plots of land. This reduces the risk of insect plagues. Crop diseases then spread less rapidly too. Furthermore, **crop rotation** is practised in organic farming. The same crop is never grown in the same field for two years in a row. This also reduces the risk of disease and plagues. Figure 5 gives the key features of organic farming.

fig. 5

Organic farming

Organic arable farming and horticulture:

- do not use chemical fertilizers;
- use manure from organic livestock farming only;
- do not use more fertilizer than the plants can absorb;
- do not have monocultures;
- do not use chemical crop protection agents.

Protect food crops against disease and pests by:

- rotating the crops;
- growing different types of food crops on small pieces of land;
- fighting insect plagues using natural enemies.

Organic livestock farming:

- makes sure that there is space for the animals to roam free (free-range animals);
- uses organically grown feed for the animals;
- pays attention to the well-being of the animals;
- only uses veterinary medicines when an animal is sick.

Organic products:

- do not contain residues of chemical crop protection agents;
- do not contain artificial aromas, chemical colourings or chemical flavourings.

EXERCISES

1 Figure 6 shows a cranefly and its larva. Cranefly larvae (sometimes called leatherjackets) mainly live in moist grassland, two to three centimetres under the ground. They eat the young roots of grasses. This leads to bare spots in the grassland. Grassland in the Netherlands is usually a monoculture. The craneflies are easily able to reproduce there.

a Why can the number of cranefly larvae rapidly increase in grassland?

b Cranefly larvae are sometimes tackled using chemical pesticides. It does not kill all the cranefly larvae. Leatherjackets are eaten by starlings.
After a while, which organism contains the highest concentration of pesticides?

○ A A leatherjackets, because it eats the grass with pesticides on.
○ B A cranefly, because it grew from a larva.
○ C A starling, because it eats a lot of leatherjackets.

fig. 6

1 cranefly

2 leatherjacket (cranefly larva)

2 **a** Why do crops in monocultures often suffer from diseases?

b In the past there used to be small woods and hedgerows between the fields. During the twentieth century, these small fields were combined to make big fields. The woods and hedgerows disappeared as a result. The number of species of small insect-eating birds has become less in areas with monocultures.
Give two possible reasons for this.

c Does this increase or decrease the chance of insect plagues? Explain your answer.

3 The Belgian ecologist and environmental activist Stijn Bruers is critical about organic farming. He says that animal manure comes from animals that emit greenhouse gases. These animals also eat soya that rainforests were cut down for at the other side of the world. He is in favour of chemical fertilizers because you can apply them very precisely.

a Give an argument for using animal manure.

b Can you use Stijn Bruers' arguments to say that chemical fertilizer is better than animal manure?

c Explain why there would be less room for nature in the Netherlands if all arable farming was organic.

4 Crop protection agents and manure are absorbed in the soil.

a What disadvantage do biocides have for useful organisms in the soil?

b Explain why using artificial fertilizers can harm our drinking water.

5

a Do these concepts belong with organic or conventional farming?
- chemical pesticides *organic / conventional*
- animal manure *organic / conventional*
- fertilizer *organic / conventional*
- mechanic weeding *organic / conventional*
- monoculture *organic / conventional*
- crop rotation *organic / conventional*

b What are the advantages of monocultures?

c What are the disadvantages of monocultures?

6

a Horticulture is often done in buildings or on roofs. The amount of carbon dioxide in the air is controlled in many greenhouses.
In what process in plants is carbon dioxide important?

b You can often see greenhouses with lights burning brightly, especially in winter.
Explain why this makes the plants in the greenhouses grow more.

c Many tomato growers let bumblebees fly around in their greenhouses.
Why are the bumblebees important?

d Environmental organizations think we should eat seasonal vegetables rather than vegetables from greenhouses all year round.
What do you think?

7

Have a look at the text in figure 7 and read it carefully.

a Explain what the manure surplus is.

b Explain how you could limit the manure surplus by making changes to the animals' feed.

c Explain how you can reduce the manure surplus by manure processing.

fig. 7 The manure surplus.

1 manure surplus

Farmers use manure for fertilizing their fields and pastures. The use of animal manure is legally restricted because too much manure is bad for the environment. The remaining manure is called the manure surplus.

2 measures to tackle the manure surplus

through feed
Animals get adjusted feed so that the manure will contain less phosphate.

through manure processing
The manure is processed into e.g. fertilizer.

through export
The manure is processed to make it suitable for export.

Go to the *Flash cards*.

Learning how to do research

1 DESCRIPTIVE RESEARCH

► Basics 1 | ► Learning objective 6.0.17

In a descriptive study, you describe a situation or phenomenon. A hypothesis is not usually needed. Figure 1 gives an example of a descriptive study.

fig. 1

The steps in a descriptive study

1 The purpose of the research: what do you want to achieve with your study?
About half of the bee species in the Netherlands are endangered or have already disappeared. You want to help conserve bee species. You want to do this by making your garden bee-friendly. A bee-friendly garden has a lot of flowers that bees can get nectar and pollen from. You write down: *The aim of the study is to get more bees in my garden.*

2 The study question: what do I want to investigate?
You want to know what plants you have in your garden now, and in particular how many of them are bee-friendly. So you ask yourself, *How many bee-friendly and bee-unfriendly plants do I have in my garden?*

3 The work plan: what am I going to do?
You can look up the plant species in a botanical book. You can look up plant species on the Internet and see which are bee-friendly. You divide the plant species in your garden into ones that are bee-friendly and ones that are not. You can write down your work plan as follows:
Requirements:
☐ *a plant book*
☐ *a computer with an Internet connection*
I will look at every plant in my garden. I will look up each plant in the plant book to find out what species it is. I write that down for each plant. Then I look up each species to see whether it is a bee-friendly plant. I write this down for each plant too. I write down the number of bee-friendly and bee-unfriendly plants in a table.

4 Doing the experiment
You gather together the things you need and you do the experiment according to your work plan.

5 The results: what are my observations?
You examine the results you got when you carried out the experiment. Your table may look as follows:

	Number of plants
Bee-friendly	5
Not bee-friendly	11

6 The conclusion: what is the answer to the study question?
You use the results to draw the following conclusion: *There are over twice as many bee-unfriendly plants in my garden as there are bee-friendly ones.*

7 The discussion: how reliable are my results?

The study went according to the work plan, but during your study you discovered that you used a very outdated plant book. You do not know for certain if the book has outdated information. You write the discussion as follows:

The study went according to the work plan. The work plan was not quite right, as I turned out to be using a very outdated plant book. I should have used a botanical book that was made more recently. I think my results are reliable, but to be sure I should do this study again with a different plant book.

Just like most other studies, a descriptive study is done step by step. First, you decide the purpose of your study and formulate the study question. After that, you make the work plan.

In a descriptive study, the work plan includes at least:

- what you need for the study
- the type of data you are going to collect:
  - text (information in words)
  - figures (information in figures as a table or graph)
  - drawings
  - photos
- how you are going to collect the data:
  - your own visual observations
  - making measurements
  - doing a survey

When you have made work plan, carry out the study according to the plan. The data you collect is your results. You use the results to draw a conclusion. Then you write the discussion, assessing how reliable your results are. You do that by checking that everything went according to the work plan and whether the work plan was correct.

EXERCISES

1 Figure 2 shows a research table of a water study that was done by a pupil.

a Why is this a descriptive study?

b What type of data does the pupil collect?
figures / *photos* / *drawings* / *text*

c How has she collected this data?

d On the graph paper in figure 3, show the relationship between the time of day and the oxygen level of the pond water.

e What oxygen level would you expect water in the overturned jar to have? Read it from the line chart.

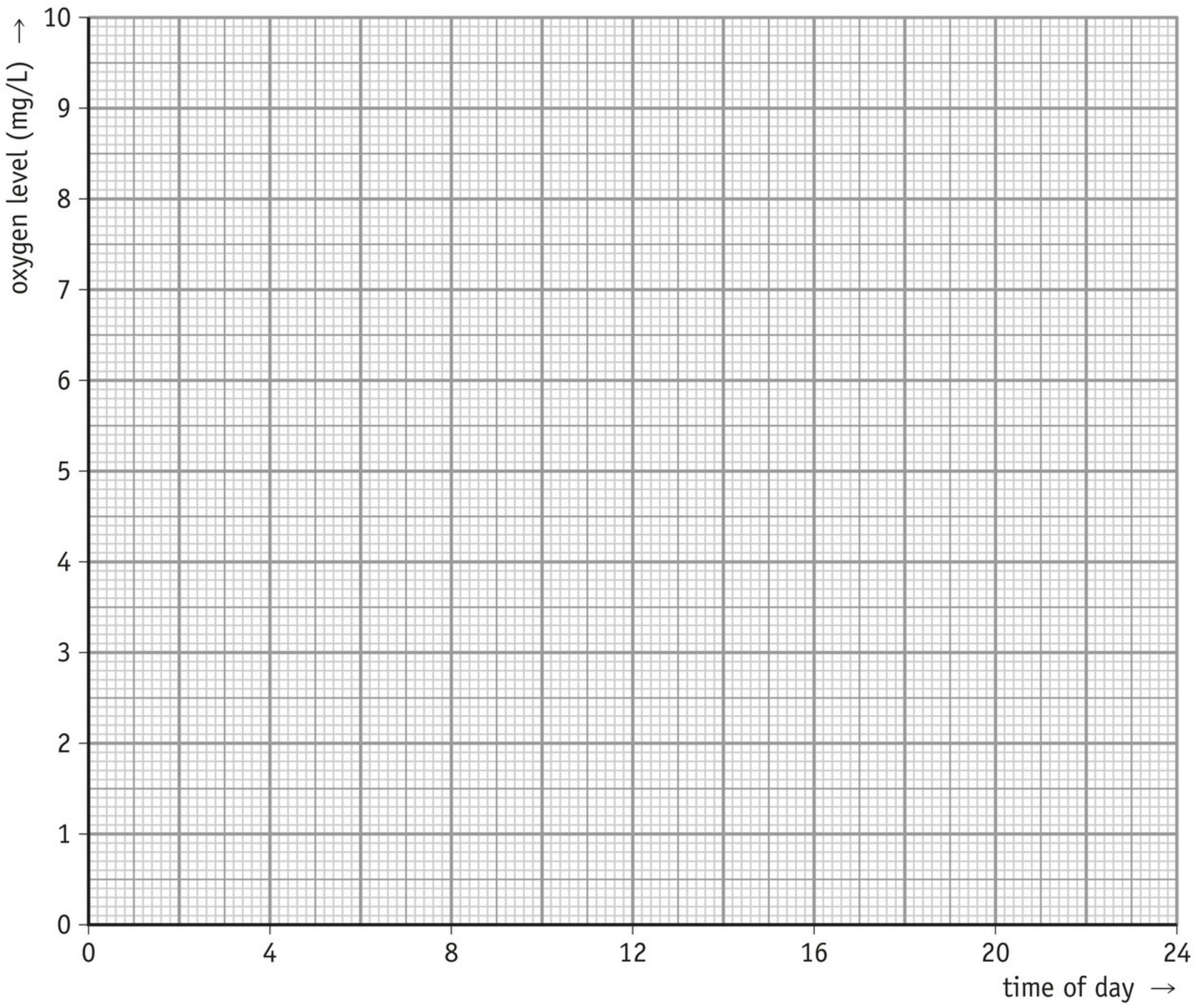
fig. 2

STUDY	THE OXYGEN LEVEL OF WATER IN A POND
Study question	How does the oxygen content of the water change over the course of one day?
What do you need?	☐ seven sample jars ☐ oxygen meter ☐ labels
Work plan	At various times during the day, I will take a sample of the pond water. I will put a label on each sample jar showing the time I took the sample. I will take the jars with me to school and measure the oxygen level in each sample using an oxygen meter.
Results	

Time	Oxygen level (mg/L)
03:30	3.6
07:15	4.3
10:40	–*
13:30	8.2
17:00	9.2
20:20	7.5
23:20	5.3

* Could not be measured because the jar was knocked over.

fig. 3 The oxygen content of the water in a pond.



2 Read the text 'Road traffic noise disturbs breeding birds' in figure 4.

a Complete the research table for this study (see figure 5).

b Why is this a descriptive study?

fig. 4

Road traffic noise disturbs breeding birds

Researchers from the Institute for Woodland and Nature Research have been comparing the areas that birds live in close to motorways against areas with no traffic noise. Virtually all the bird species studied had their breeding success reduced by 10% when the traffic intensity was ten thousand vehicles a day (which is a not particularly busy motorway). Why traffic noise affects birds' breeding is not clear. It is possible that birds are then less able to hear signals that are important for them, such as alarm calls, songs for marking out territories, and the sounds made by prey animals.

fig. 5

STUDY	BREEDING BIRDS AND ROAD TRAFFIC NOISE
Study question	
Work plan	
Results	
Conclusion	

3 One effect of global warming is an increase in the number of ticks in the countryside. Ticks can carry the *Borrelia* bacterium. This bacterium causes Lyme disease. Figure 6 is a research table of a descriptive study that was carried out by tekenradar.nl.

a A hypothesis is not mandatory in a descriptive study.
Why is it useful to have a hypothesis for this study anyway?

b Write down the study conclusion in the research table.

c Can you say that the hypothesis has been confirmed? Explain your answer.

d A red ring on the skin after a tick bite is evidence of Lyme disease. Table 1 shows how many people throughout the Netherlands have been seen by the GP with a red ring or spot on their skin since 1994.
Does this data confirm the study hypothesis? Explain your answer.

fig. 6

STUDY	LYME DISEASE
Study question	Why are more people getting Lyme disease every year?
Hypothesis	The proportion of infected ticks in the Netherlands has increased over the years.
Work plan	The tekenradar.nl website started in 2012. Volunteers can report tick bites on tekenradar.nl and can send ticks in too. The ticks are tested for the *Borrelia* bacterium. The volunteers also say whether they got Lyme disease or not.
Results	2012: 7000 bites 3500 ticks were sent in; 18% were infected with the *Borrelia* bacterium. 1.8% of the tick bites resulted in Lyme disease. 2013: 9000 bites 1500 ticks were sent in; 20% were infected with the *Borrelia* bacterium. 2% of the 9000 bites resulted in Lyme disease.
Conclusion	

Table 1 People with a red ring on their skin who were seen by a doctor.

Year	Number per 100,000 inhabitants
1994	39
2001	74
2005	104
2009	134
2014	139
2017	148

4 You are going to think up a piece of descriptive research for yourself and then carry it out and give a written presentation.
The subject of your research could fit in with the theme of 'Ecology and sustainability', but it may also be about something else. Your teacher will tell you.

- Think what you want to investigate. Discuss with your teacher whether that is a reasonable choice.
- Write down the study question.
- Make a work plan. The work plan states:
  - what you need for your study
  - how you are going to carry out the experiment
  - the type of data you are going to collect
  - how you are going to collect the data
- Get your teacher to check the research question and the work plan.
- Carry out the study according to the work plan.
- Write down your results.
- Process your results according to the work plan.
- Write down a conclusion that answers the study question.
- Make a report of the study.

2 PREPARING A SOIL PROFILE

► Basics 4 | ► Learning objective 6.0.18

The ground that you stand on is made up of a lot of different layers. Each layer has its own features which are an important factor in determining what plants will grow there. The amounts of nutrients, water and oxygen are important properties, for example, that affect the growth of plants. In other words, the vegetation of any given area is partly determined by the soil.

You will be using an earth drill to create a **soil profile** (see figure 7). You do that as follows:

- Remove any vegetation around the spot where you want to drill.
- Using the earth drill, drill three half turns into the ground.
- Pull the earth drill out of the ground, take the soil off it and lay the soil out flat next to the hole.
- Place the earth drill in the hole again and drill another three half turns.
- Lay out the soil from the drill like an elephant's trunk behind the first soil profile part. Make sure you have put the right ends of the soil profiles next to each other so that you have a complete profile of the soil after you have finished.
- Drill down until you have a drill hole that is one metre deep. That is roughly how deep plant roots grow down to.

fig. 7 A soil profile.

Practical activities

1 COLLECTING AND IDENTIFYING SOIL CREATURES

► Basics 1 | ► Learning objective 6.1.3

40-50 minutes

In many ecosystems, the soil is covered with a layer of twigs and leaves that have fallen off the trees. That is called **plant litter**. A lot of small creatures live in the layer of plant litter and the top layer of soil. You will find a lot of soil creatures there, especially on warm afternoons.

WHAT ARE YOU GOING TO DO?

In this practical activity, you will identify animals that live in the plant litter and the soil. You will collect the animals on the day of your practical activity, before the lesson starts. Try to do this practical activity on a warm afternoon. You will find more small animals then than on a cold day.

WHAT DO YOU NEED?

- ☐ 2 glass jars
- ☐ a trowel
- ☐ a large sheet of paper
- ☐ a brush
- ☐ a comparison chart, a reference book, the Internet or an app for finding the names of the animals in the soil

WORKING METHOD

- Before the lesson starts, find a place in the area around your school where you can investigate the plant litter layer.
- Collect a little plant litter in one of the glass jars.
- Dig up a small piece of soil down to about 10 cm deep and put that in the other glass jar (see figure 1).
- Take the jars back to the classroom with you.
- Empty the jar of plant litter onto the sheet of paper. Clean the jar.
- Search for small animals by carefully brushing the plant litter from one side of the paper to the other (see figure 2).
- Try to find the name for each animal. Write down the animal species you found in the table. Write down the numbers of individuals for each species too.
- Put the animals that you found back in the glass jar. Clear away the plant litter.
- Empty the jar of soil material onto the sheet of paper and clean the jar.
- If the soil is a single lump, you will have to break it carefully into very small pieces.
- Search for small animals by carefully brushing the soil from one side of the paper to the other. Try to find names for these animals as well. Write down the animal species you found in the table, and how many individuals you found of each species.
- Put the animals that you found back in the glass jar and clear away the soil.

Ecosystem:			
In the plant litter		In the topsoil	
Animal species	Number	Animal species	Number

fig. 1 Taking a sample.

fig. 2 Collecting the soil animals.

2 LICHENS

► Basics 3 | ► Learning objective 6.3.7

20-30 minutes

WHAT ARE YOU GOING TO DO?

In this practical, you will be using a microscope to examine a specimen of a lichen (pronounced the same as 'liken'). You will be making a drawing of the structure of a lichen.

WHAT DO YOU NEED?

- ☐ a piece of lichen
- ☐ a microscope
- ☐ preparation materials
- ☐ drawing materials

WORKING METHOD

- Cut several thin slivers off the lichen and make a specimen slide of it. It is not possible to cut good slivers off some types of lichen. In that case, use two mounted needles to carefully separate out a small piece of lichen and make your preparation from that.
- Examine the slide at a magnification of 100×.
- Find a piece where you can see both algae and fungal threads. Examine this at a magnification of 400×.
- Make a drawing of it. Label the algal and fungal cells in your drawing.

3 PREPARING A SOIL PROFILE

► Basics 4 | ► Learning objective 6.0.18 | ► Learning how to do research 2

60-70 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will be using an earth drill to create a soil profile for woodland, grassland, roadside verges or some other kind of soil.

WHAT DO YOU NEED?

- ☐ an earth drill
- ☐ a pencil
- ☐ a sheet of paper

WORKING METHOD

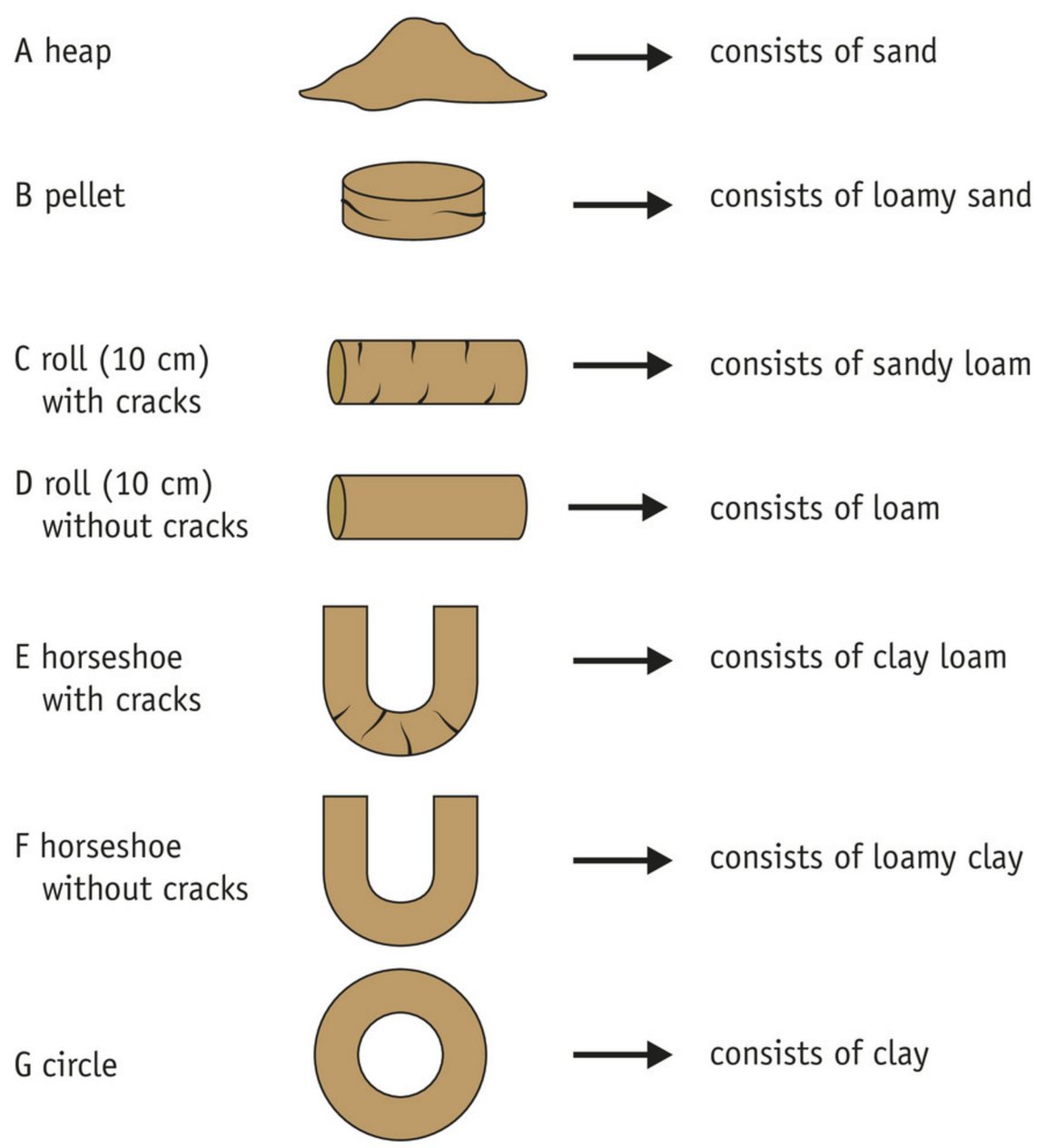
- Make a soil profile. Use the information in 'Learning how to do research 2'.
- Drill down until you have a drill hole one metre deep.
- Draw the profile on paper, showing the colours.
- Write down the following in the correct columns of the earth-drilling table:
  - the colour (use the soil as if it was finger paint and smear the colour into the appropriate cell)
  - what you can see (granules, pebbles, roots, twigs, rotting plant remains, rust spots)
  - how it feels (hard, soft, grainy, dry, moist, wet, sticky)

- Try to make a heap, pellet, roll, horseshoe and circle with the soil (see figure 3).
- Write down the soil type in the final column.

Earth drilling	Colour	What do you see?	What does it feel like?	Soil type
Depth				
to cm				
to cm				
to cm				
to cm				
to cm				

fig. 3 Soil types.
Try to make a heap, pellet, roll, horseshoe and circle with the soil.
Then use the diagram below to find out what soil type you have.

Table for the soil type:



4 FINE PARTICULATES IN YOUR REGION

► Basics 5 | ► Learning objective 6.5.10

15-25 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will be recording the levels of fine particulates in your region for two weeks. You can find this information on the Dutch teletext on page 711. The data for each region can be found on one of the subpages. You can access teletext via the TV, the Internet or the 'teletekst' app. So you can do this practical activity at school or at home.

WHAT DO YOU NEED?

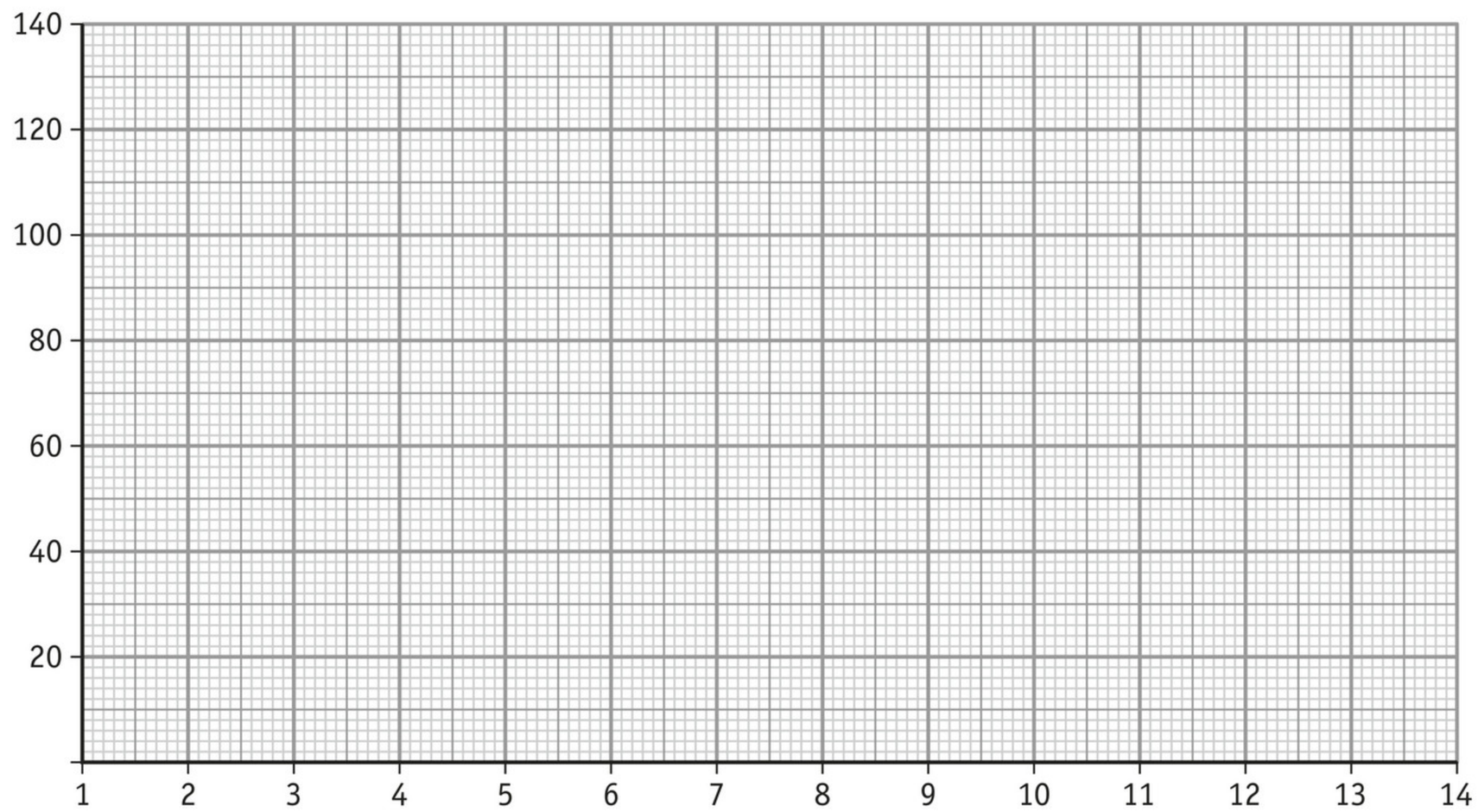
☐ a TV, a computer with the Internet or a mobile phone with the 'teletekst' app

WORKING METHOD

- Every day, look up the following on the teletext:
  - the expected values for fine particulates in your region
  - the temperature (see teletext page 705)
  - the wind strength (see teletext page 705)
- Write down the date and the teletext data in the table every day.
- Use the data to draw a line graph showing the levels of fine particulates over time.

Date														
Fine particulates (µg/m³)														
Temperature (°C)														
Wind strength (m/s)														

fig. 4 Line graph of fine particulates.



EXERCISE

1 The temperature and wind can affect the amounts of fine particulates in the air. The concentration of fine particulates in the air increases when temperatures are high and there is not much wind.

a Can you draw this conclusion from your own results? Explain your answer.

b Look at the levels of fine particles and ozone for the past fourteen days. What can you say about the smog class in your region during this period?

c What consequences would the smog class on day 14 of your study have for people with a lung condition?

5 BIODEGRADABLE WASTE

► Basics 5 | ► Learning objective 6.5.10

Lesson 1: 15-20 minutes, lessons 2 to 6: 5 minutes, lesson 7: 5-10 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will be investigating whether aluminium foil, apple peel, a plastic sandwich bag and toilet paper are biodegradable. You will also investigate a product that you have chosen yourself.

WHAT DO YOU NEED?

The things you need are given in the table.

WORKING METHOD

Do the experiment and complete the rest of the table.

STUDY	BIODEGRADABLE WASTE
Aim of the study	
Study question	Are aluminium foil, apple peel, a plastic sandwich bag, toilet paper and biodegradable?
Hypothesis	
What do you need?	☐ 5 jam jars ☐ 5 labels ☐ garden soil ☐ water ☐ a knife ☐ aluminium foil ☐ apple peel ☐ a plastic sandwich bag ☐ toilet paper ☐

Working method

- Take five jam jars and stick a label on each jar.
- Put a generous quantity of soil in each jar (see figure 5). Moisten the layer of soil a little.
- Cut or tear the waste into pieces. Take each kind of waste and put a little bit into one of the jars. Mix the waste in with the soil, using the knife. Write what kind of waste you have added to the jar on the label.
- Put the jars in storage.
- Check every week for six weeks to see what has happened to the waste. Do this on the same day each week.
- Record what has happened to the waste in the table, Use the terms: *decomposed* (+) – *decomposed a bit* (±) – *still no change* (–).
- Make sure the soil remains slightly moist throughout the experiment.

fig. 5

Result

Time	Type of waste				
	Aluminium foil	Apple peel	Plastic sandwich bag	Toilet paper	product you chose
After 1 week					
After 2 weeks					
After 3 weeks					
After 4 weeks					
After 5 weeks					
After 6 weeks					

Conclusion

The following kinds of waste are biodegradable:

The following kinds of waste are not biodegradable:

Discussion

Does your conclusion fit your hypothesis? *yes* / *no*
The hypothesis has been *confirmed* / *rejected*.

Did everything go according to the working plan? If not, what went differently?

Was the work plan in order? If not, what could have been done better?

How reliable are your results?

6 LITTER IN AND AROUND YOUR SCHOOL

► Basics 5 | ► Learning objective 6.5.10

Lesson 1: 10-15 minutes, lesson 2: 10-15 minutes

WHAT ARE YOU GOING TO DO?

The anti-litter organization Nederland Schoon took photos at several spots in and around schools and asked people to give a score of 1 to 5 for how much litter there was (see table 1).
Figure 6 shows ten examples in and around a school with the average scores people gave.
In this practical activity, you will examine the amount of litter in and around your school and give it a score.
Do this practical activity together with a classmate.

Table 1

Very dirty	score 1
Dirty	score 2
Fairly clean	score 3
Clean	score 4
Very clean	score 5

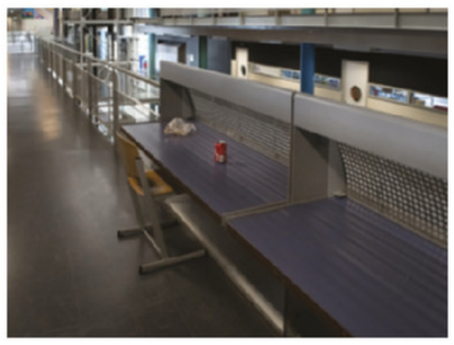
fig. 6

Inside the school

score 1 very dirty

score 2 dirty

score 3 fairly clean



score 4 clean

score 5 very clean

Outside the school

score 1 very dirty

score 2 dirty

score 3 fairly clean

score 4 clean

score 5 very clean

WORKING METHOD

- Choose four spots inside the school and two spots outside the school, after discussing them with your teacher. Also choose the time of day when you will give the spots a score. For example, where people go for their lunch break, before and after the break.
- Write the locations and times down in the table.
- Give a joint score for the amount of litter (from 1 to 5), with the help of the photos in figure 6. When you give your score, you must only look at the litter. So you should not take other things into account such as a dirty wall or dog poo.
- Compare your scores with your classmates. Discuss your scores together.

Location	Time	Score
1		
2		
3		
4		
5		
6		

7 FOOD FOOTPRINT

► Basics 6 | ► Learning objectives 6.6.13 and 6.6.14

30-40 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will be investigating the food footprint of your class. Your food footprint is part of your environmental footprint. In this practical activity, you will also look at what you can do to reduce the class's food footprint. You do not need to think of a hypothesis.

WHAT DO YOU NEED?

The things you need are given in the table.

WORKING METHOD

Do the experiment and complete the rest of the table.

STUDY	FOOD FOOTPRINT
Aim of the study	Reduce the class's food footprint.
Study question	What is the class's food footprint and how can we reduce it?
What do you need?	☐ a computer, mobile phone or tablet with Internet
Working method	• Go to the website of the Voedingscentrum (Netherlands Nutrition Centre) and enter 'voedselafdruk' (food footprint) as the search term. You will find a test with fifteen questions to determine your food footprint. • Do the test. If a question doesn't apply to you, try to answer it for your parents, guardians or housemates. • In the first table, write down the number of hectares of farmland and the number of litres of water per day for your food footprint. Also write down the challenges the Voedingscentrum gives you for reducing your food footprint. • Collect the data of all your classmates. • Calculate the total food footprint for the class. Also calculate the average food footprint per pupil. Write these numbers down in the second table. • In the third table, write down all the challenges the class was given and how often each challenge was mentioned.
Result	

	My food footprint
Farmland (ha)	
Water (L per day)	

Challenges:

•

•

•

	Farmland (ha)	Water (L per day)
Total		
Average per pupil		

Challenge	Number

Conclusion	
Discussion	Did everything go according to the work plan? For example, did all the pupils in the class do the test? Could you answer all the questions? Was the work plan in order? If not, what could have been done better? How reliable are your results?

Summary

BASICS 1

ORGANISMS AND THEIR ENVIRONMENT

1 **You can classify the influences on organisms into biotic and abiotic factors.**
- biotic factors: influences that come from living nature, such as others of the same species, predators, pathogens.
- Abiotic factors: influences that come from non-living nature, such as soil characteristics, light, rainfall, temperature, wind, oxygen level in the air.

2 **You can describe the levels of ecology.**
- Organism (individual): a living being.
- Population: a group of organisms of the same species that live together in an area.
- Ecosystem: a specific area with all the organisms living in it, in which the biotic and abiotic factors form a unit.
  - community: all the populations in the ecosystem
  - biotope: all the abiotic factors in the ecosystem
- Biosphere: the part of the Earth (and the air around it) where life is possible.

3 **You can indicate the various feeding relationships in an ecosystem.**
- Biomass: the total amount of all the high-energy substances in an organism.
- Food chain: a series of organisms in which each organism is the food source for the next.
  - All food chains begin with a green plant.
- Food web (food network): all the food chains in an ecosystem.
  - In a food web, the food chains are interrelated and form a network.
- Accumulation: the progressive build-up of substances in each subsequent link in a food chain.

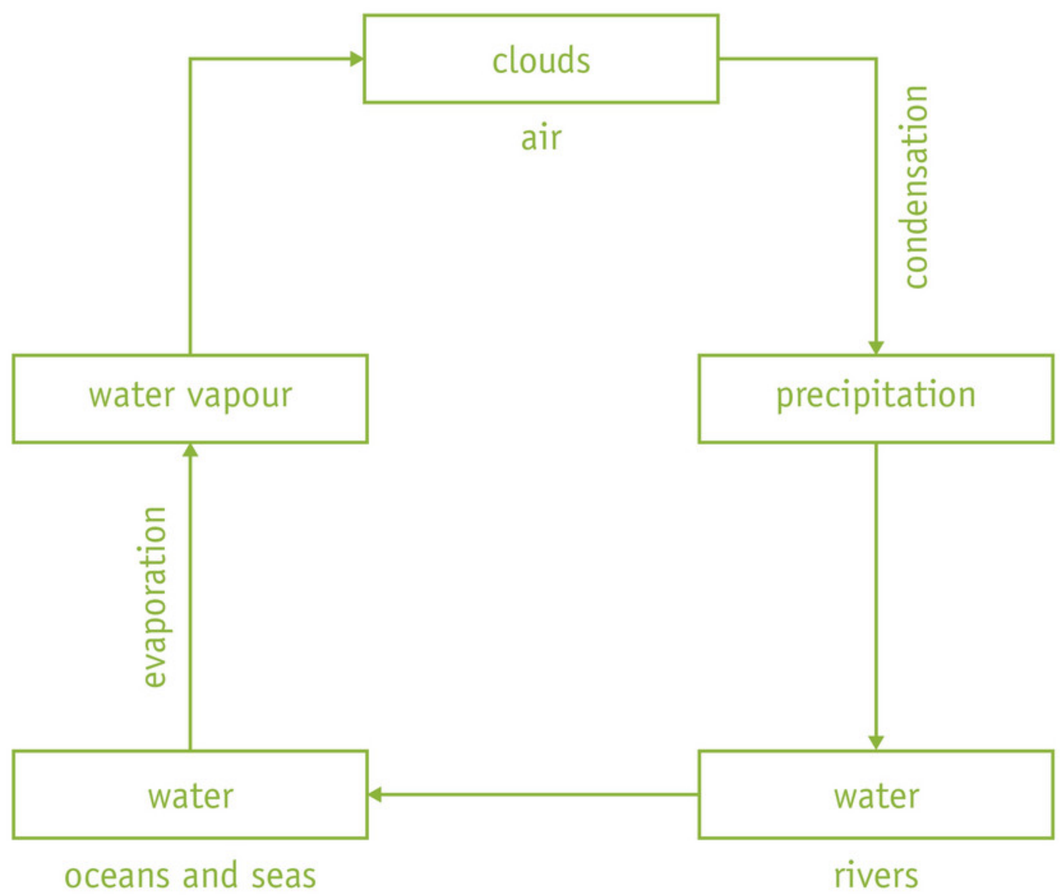
BASICS 2

FEEDING RELATIONSHIPS AND CYCLES

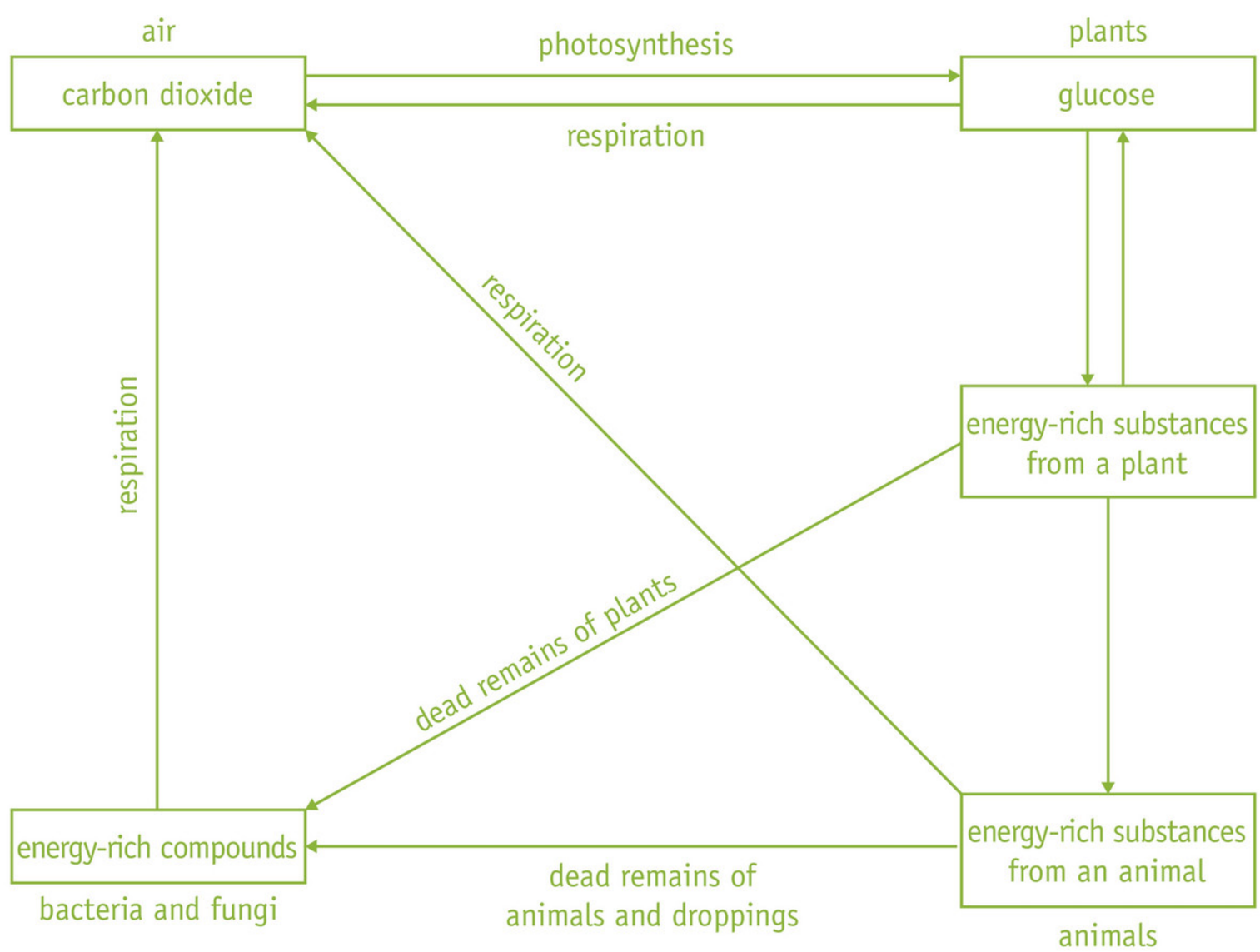
4 **You can describe the groups of organisms in the nutrient cycle.**
- Producers: provide the food for all other organisms.
  - Plants are producers. Photosynthesis takes place in the green parts of plants.
- Consumers: eat the materials made by plants.
  - First-order consumers are eaten by second-order consumers that are eaten by third-order consumers, etc.
  - Herbivores, carnivores, omnivores and scavengers are all consumers.
  - Animals are consumers.
- Breakdown agents: break down dead organisms and their wastes.
  - This releases minerals that are reused by the producers.
  - Bacteria and fungi are ‘decomposers’ (breakdown agents).
- Biodegradable waste: waste that can be degraded by breakdown agents (bacteria and fungi).
  - waste material from plants, animals (including humans) such as leaves, bread crusts, fruit peel and rinds, paper, faeces
- Non-biodegradable waste: waste that cannot be degraded by breakdown agents.
  - Only humans produce non-biodegradable waste, such as batteries, glass, metal, plastic packaging

5 You can describe the water cycle and the carbon cycle.

- The water cycle.



- The carbon cycle.



BASICS 3

LIVING TOGETHER

6 You can explain what a biological equilibrium is.

- Biological equilibrium: a situation where the size of each population is balanced, fluctuating around a certain value.
  - The size of each population depends on biotic and abiotic factors.

7 You can explain how species depend on each other for food, shelter and reproduction.

- Each individual has relationships with other individuals.
  - competition, for instance for food, partners or safe places to hide
  - cooperation, for instance in hunting or mating.
- There is often little competition between populations of different species, because the species specialize.

- Symbiosis: a long-term relationship between individuals of different species.
  - mutualism: both individuals benefit from the relationship (lichens, for example)
  - commensalism: one individual benefits and the other is not affected, e.g. Pleurococcus (green algae on trees)
  - parasitism: one individual benefits and the other is negatively affected, e.g. ticks

BASICS 4

NATURE MANAGEMENT

8 You can explain that a lot of nature in the Netherlands was created by human intervention.

- People depend on their living environment (their surroundings) for food, water, oxygen, energy, raw materials and recreation.
- The landscape of the Netherlands is a cultural landscape.
  - Cultural landscape: formed by past human activities such as agriculture (pastures), energy generation (wood), water management (dykes, ditches).

9 You can list ways in which people in the Netherlands manage, protect and restore nature.

- Biodiversity is the variation of species in nature.
- Nature management: maintaining, protecting and restoring areas not used for living, working, agriculture or traffic.
- Reintroduction: bringing an animal or plant species back to a country.
- Nature management measures:
  - reintroduction, e.g. stork, beaver.
  - protection by mowing later, e.g. meadowland birds
  - chopping down trees, e.g. to prevent heathland from becoming overgrown
  - shooting (hunting), e.g. geese at Schiphol Airport
  - water management, e.g. widening rivers

BASICS 5

HUMANS AND THE ENVIRONMENT

10 You can describe several causes and consequences of exhaustion and pollution.

- Causes of environmental problems.
  - population growth: more people need more food, energy and raw materials
  - way of life: consumption, industry, equipment and transport
- Humans can affect the environment by:
  - removing substances from the environment, which leads to exhaustion (e.g. raw materials)
  - adding substances to the environment, which leads to pollution (e.g. waste)
- Exhaustion: of energy sources, raw materials, agricultural land.
  - Fossil fuels and raw materials are starting to run out.
  - Monoculture: a large area where just one crop is grown.
- Pollution: air pollution, soil pollution, water pollution, such as:
  - nitrogen from fertilizers in the air
  - industrial toxins in the soil
  - heavy metals in the groundwater

11 You can describe several causes and consequences of climate change.

- Enhanced greenhouse effect: warming of the Earth because more greenhouse gases are being released into the atmosphere.
  - The most important greenhouse gases are carbon dioxide and water vapour.
  - Causes include fossil fuels, livestock farming and deforestation.
- Climate change caused by global warming.
  - cause: the enhanced greenhouse effect
  - consequences: include extreme weather, flooding, drought, sea level rises, salinification, disruption of the biological equilibrium in ecosystems
- Changes in nature: biodiversity decreases.
  - Up to a million species are threatened with extinction.

BASICS 6

SUSTAINABILITY

12 You can compare the ecological footprint of the Netherlands to that of other countries.

- Ecological footprint: the surface of the Earth that is needed for your food, energy, raw materials and waste.
  - The size of your footprint depends on your lifestyle and consumption pattern.
  - For each person on the planet, 1.7 ha is available (1 ha = 100 × 100 m).
  - The average footprint of every person on the Earth is 2.6 ha.
  - The average footprint of people in the Netherlands is 6.3 ha.

13 You can explain what sustainability is.

- Sustainability:
  - not taking more substances from the environment than the environment can replenish
  - not adding more substances to the environment than the environment can process
- Sustainable development: using what we need while passing the Earth to the next generations in the same state.

14 You can state what would be sustainable solutions for environmental problems in the Netherlands.

- Sustainable energy: the energy source does not get exhausted and causes less (or zero) environmental pollution.
  - biomass: as fuel for generating electricity, as raw material for biofuel.
  - electricity from wind energy, solar energy and geothermal heat
- Sustainable agriculture:
  - organic farming: no monocultures, no chemical fertilizer, no chemical crop protection agents
  - urban farming: food production in the city (next to, inside or on the roofs of buildings)
  - vertical farming: plants in trays on top of each other with LED light, which is often coloured
  - precision farming: using technology to increase the yield
- Less pollution: measures by the Dutch government and the countries of the European Union.
- Less greenhouse gases: using less energy from fossil fuels, e.g. through electric cars and scooters, insulation, energy-efficient devices.

EXTRA 7

THE ENERGY FLOW IN AN ECOSYSTEM

15 You can describe the energy flow in an ecosystem.

- Autotrophic organisms: have chlorophyll and can create energy-rich compounds through photosynthesis.
  - Autotrophic organisms do not require other organisms as their food.
- Heterotrophic organisms: take up energy-rich and energy-poor compounds from their environment.
  - Heterotrophic organisms require other organisms for their food.
- The energy flow in an ecosystem: energy disappears from a food chain in each link in the food chain.
  - Some individuals die without getting eaten by individuals of the next link.
  - Some parts of individuals that are eaten are not digested. This part ends up in the faeces.
  - Some of the substances that are digested are used as fuel. Burning them releases energy, usually in the form of heat or motion.
  - The remaining part can be used as building materials. This is the part that can act as food for the next link up in the food chain.

EXTRA 8

FOOD PRODUCTION

16 You can describe agriculture in the Netherlands.

- Food crops: plants that are grown in arable farming and horticulture.
- Farm animals, livestock: animals that are kept for livestock farming.
- Increasing the yields of food crops and farm animals:
  - fertilizing and processing the soil
  - protecting crops against diseases and pests
  - giving farm animals special feed
  - protecting farm animals against diseases
  - crossing, breeding or using techniques from biotechnology on plants or animals
- Arable farming:
  - Large farms with a lot of land.
  - The food crops are grown in monocultures.
  - Advantage of monocultures: large machines can be used.
  - Disadvantages of monocultures: there is a big risk of plagues of insects and disease, and the soil gets exhausted quickly.
- Crop protection: protecting plants against disease and pests (often insects).
  - Chemical crop protection agents: biocides.
  - Biocides are often non-selective (they also kill useful organisms).
  - Organisms can become resistant to biocides.
  - Biocides can end up in the food chain, resulting in accumulation.
  - Organic crop protection, e.g. using natural enemies.
- Features of organic farming.
  - There are no monocultures.
  - Chemical fertilizers are not used.
  - No chemical crop protection agents are used.
  - Crop rotation is also practiced.
  - Animals get space to roam free (free-range animals).

RESEARCH

LEARNING HOW TO DO RESEARCH & PRACTICAL ACTIVITIES

17 You can do a descriptive study.

18 You can make a soil profile.

Go to the *Flash cards* and the *Diagnostic test*.

Caring for

In this project, you will think up, prepare, carry out and present your own research. The project will take about four lessons. You will be working as a group of three and working on the project outside classroom hours too.

Making the school greener

AIM OF THE STUDY

The aim of your study is to help make your school 'greener' – more sustainable. You can pick one of the following four themes:

- waste and recycling
- biodiversity around the school
- renewable energy in the school
- sustainable nutrition

You will be studying how green your school is (or not, as the case may be). You could for instance do a literature study into green energy for schools, or perhaps map out the biodiversity on your school premises. Or maybe look to see what is done with the waste from the canteen. Whatever you can think up! You conclude your research with some recommendations for the school board: things they could do to make your school even more sustainable.

DOING THE STUDY

On the right are the research skills you have learned. Use at least ten of them during the project. Keep track of the skills you have used too.

- Pick one of the four themes that you want to do the study in.
- Think about what you want to investigate. Think together about the type of study that you want to use. Talk to your teacher to see if your idea is achievable.
- Prepare the research as you have been taught. Get the teacher to check your preparations.
- Carry out the study using the steps you have learned.
- Present your study. Make sure it includes your recommendations to the school board. The teacher will decide whether the study is to be presented in writing or verbally.

the future

RESEARCH SKILLS

General

1 You know the various types of scientific research.
2 You can describe the steps in scientific research.
3 You can determine which type of study is the most appropriate.
4 You can carry out a literature review.
5 You can do a descriptive study.

Research

6 You can formulate the research goal (with help).
7 You can formulate a research question (with help).
8 You can formulate a hypothesis.
9 You can make a work plan for a practical activity (with help).
10 You can carry out research according to a work plan.
11 You can make measurements accurately.

Results and conclusion

12 You can determine what kind of graph is most suitable for showing your results.
13 You can present your results as a bar chart, line graph or pie chart.
14 You can process results (digitally) into a table or a chart.
15 You can draw one or more conclusions that answer the study question.
16 You can evaluate the hypothesis by comparing it against the conclusion.
17 You can evaluate whether the results are reliable.

Presentation

18 You can give a verbal presentation of a study.
19 You can give a written presentation of a study.

Glossary

A

abiotic factor abiotische factor
Invloed van de levenloze natuur.

abortion abortus
Ingreep om een zwangerschap af te breken.

accumulation accumulatie
Opeenhoping van giftige stoffen.

afterbirth nageboorte
Uitdrijving van de placenta, resten van de navelstreng en vruchtvliezen.

agriculture landbouw
Land dat door de mens wordt gebruikt voor de productie van voedsel.

agriculture landbouw
Alle activiteiten waarbij het natuurlijk milieu wordt aangepast voor de productie van planten en dieren voor menselijk gebruik.

AIDS aids
Soa die het afweersysteem aantast.

air pollution luchtvervuiling
Vervuiling van de lucht door voornamelijk smog en fijnstof.

albino albino
Mutant waarbij het lichaam niet in staat is pigment te vormen.

allele (gene variant) allel (genvariant)
Informatie in een gen.

allele pair allelenpaar
Twee allelen van een gen.

amniotic fluid vruchtwater
Vloeistof die een embryo beschermt tegen stoten, uitdroging en wisseling van temperatuur.

amniotic sac vruchtvlies
Vlies om een foetus .

anomaly scan 20-wekenecho
Echo waarbij een foetus wordt onderzocht op verschillende aangeboren afwijkingen aan het hart, de hersenen, de organen en de ledematen.

asexual aseksueel
Je niet seksueel aangetrokken voelen tot anderen.

assault aanranding
Met geweld of onder bedreiging seksuele handelingen verrichten.

autotrophic autotroof
Geen andere organismen als voedsel nodig hebben.

B

base base
Bouwsteen van DNA.

base pair basenpaar
Paar van de basen A-T of C-G.

biocide biocide
Chemisch gewasbeschermingsmiddel dat levende organismen doodt.

biodegradable biologisch afbreekbaar
Door reducenten afbreekbaar.

biodiversity biodiversiteit
Variatie aan soorten in de natuur.

biological equilibrium biologisch evenwicht
Schommelend evenwicht van de populatiegrootte in een ecosysteem.

biomass biomassa
Energierijke stoffen in organisch materiaal.

biomass biomassa
Totale hoeveelheid energierijke stoffen in een organisme.

biosphere biosfeer
Alle ecosystemen samen.

biotechnology biotechnologie
Verzamelnaam voor technieken waarbij organismen worden gebruikt om producten te maken voor de mens.

biotic factor biotische factor
Invloed van de levende natuur.

biotope biotoop
Alle abiotische factoren in een bepaald gebied.

bisexual biseksueel
Je seksueel aangetrokken voelen tot zowel mannen als vrouwen.

blue-green algae blauwalg
Bacterie die stoffen maakt die giftig zijn voor mensen.

body cell lichaamscel
Cel die onderdeel is van je lichaam.

breakdown agent reducent
Organisme dat dode resten van andere organismen afbreekt.

breech presentation stuitligging
Ligging in de buik waarbij het kontje of een voetje van het kind als eerste naar buiten komt.

C

caesarean keizersnede
Operatie waarbij een kind via de buikwand ter wereld komt.

cancer kanker
Kwaadaardige tumor.

cell division celdeling
Vorming van nieuwe cellen.

chance of survival overlevingskans
Kans dat een organisme in leven blijft.

chemical crop protection agent
chemisch gewasbeschermingsmiddel
Gifstof die voedingsgewassen beschermt tegen vraat.

chemical fertilizer kunstmest
Mest die kunstmatig wordt gemaakt in laboratoria of fabrieken.

childbirth bevalling
Geboorte van een baby.

chlamydia chlamydia
Soa die ontstekingen kan veroorzaken aan bijvoorbeeld de anus, de baarmoedermond en de urinebuis.

chromosome chromosoom
Lange dunne draad in de celkern.

climate change klimaatverandering
Verandering van het gemiddelde weertype over een lange periode.

clitoral glans clitoriseikel
Gevoelig 'knopje' van de clitoris.

clitoral hood clitorishoed
Huidplooi om de clitoriseikel.

clitoris clitoris
Orgaan dat gevoelig is voor prikkels die een fijn gevoel geven.

closed-cycle agriculture kringlooplandbouw
Landbouw waarbij duurzaam wordt omgegaan met natuurlijke hulpbronnen.

coil, IUD spiraaltje
Voorbehoedsmiddel dat in de baarmoeder wordt ingebracht.

coitus interruptus (withdrawal method)
coïtus interruptus (onderbroken geslachtsgemeenschap)
Anticonceptiemethode waarbij de man zijn penis uit de vagina terugtrekt als hij zijn zaadlozing voelt aankomen.

combined test combinatietest
Prenatale test waarmee wordt vastgesteld of er een kans is op een kindje met downsyndroom.

commensalism commensalisme
Symbiose waarbij één individu een voordeel heeft van de relatie en het andere individu geen voordeel of nadeel heeft.

community levensgemeenschap
Alle populaties in een bepaald gebied.

competition concurrentie
Relatie waarbij wordt gestreden.

condom condoom
Hoesje van dun rubber dat om de penis in erectie wordt geschoven.

consumer consument
Organisme dat stoffen eet die het niet zelf heeft gemaakt.

contraception geboorteregeling
Bepalen of je een kind wil of niet.

contraceptive voorbehoedsmiddel (anticonceptiemiddel)
Middel dat zwangerschap voorkomt.

contraceptive injection prikpil
Injectie met een hormoon dat de ovulatie remt.

contraceptive inplant anticonceptiestaafje
Staafje met hormonen die voorkomen dat een vrouw zwanger wordt, dat wordt ingebracht onder de huid.

contraceptive patch anticonceptiepleister
Pleister met hormonen die voorkomen dat een vrouw zwanger wordt.

contraceptive pill ('the pill') anticonceptiepil (pil)
Pil met hormonen die voorkomen dat een vrouw zwanger wordt.

contraction wee
Krachtige samentrekking van spieren in de baarmoederwand.

cooperation samenwerking
Relatie waarbij wordt samengewerkt.

copper coil koperspiraaltje
Spiraaltje dat zaadcellen aantast en innesteling bemoeilijkt.

CRISPR-Cas crispr-cas
Techniek waarbij gericht wijzigingen worden aangebracht in bestaande genen van een organisme.

crop rotation vruchtwisseling
Landbouw waarbij op een stuk grond nooit twee jaar achter elkaar hetzelfde gewas wordt verbouwd.

cultural landscape cultuurlandschap
Landschap dat is gevormd onder invloed van de mens.

D

daughter cell dochtercel
Cel die ontstaat uit een moedercel tijdens celdeling

delivery uitdrijving
Het naar buiten persen van een kind door krachtige persweeën

delivery contraction perswee
Krachtige samentrekking van spieren in de baarmoederwand en buikwand.

dilation ontsluiting
Het wijder worden van een baarmoederhals en baarmoedermond.

DNA DNA
Stof die informatie bevat voor erfelijke eigenschappen.

DNA sequence DNA-sequentie
Volgorde van de basen in het DNA.

DNA test DNA-test
Test die DNA uit cellen onderzoekt.

dominant allele dominant allel
Allel dat altijd tot uiting komt in het fenotype.

E

ecological footprint ecologische voetafdruk
land- en wateroppervlak dat nodig is voor jouw consumptie en jouw afval.

ecology ecologie
studie van relaties tussen organismen en hun milieu.

ecosystem ecosysteem
gebied waarbinnen een levensgemeenschap en een biotoop een eenheid vormen.

eDNA eDNA
DNA dat in een bepaalde omgeving wordt verzameld.

egg cell, ovum (plural: ova) eicel
vrouwelijke geslachtscel.

ejaculation zaadlozing
Het met schokken uit de penis komen van sperma.

embryo embryo
Kindje in de eerste weken van ontwikkeling in de baarmoeder.

emotional changes geestelijke verandering
Verandering in de puberteit in je gedachten, gevoelens, zelfstandigheid en sociale leven.

endangered species bedreigde diersoort
Soort waarvan de individuen moeite hebben om in leven te blijven en zich voort te planten.

energy flow energiestroom
Doorgeven van energie tussen trofische niveaus.

energy-rich compound energierijke stof
Stof waarbij bij verbranding energie vrijkomt.

enhanced greenhouse effect versterkt broeikaseffect
Opwarming van de aarde doordat er meer broeikasgassen worden afgegeven aan de dampkring, waardoor meer warmte wordt teruggekaatst naar de aarde.

environment milieu
Leefomgeving van een organisme.

environmental problem milieuprobleem
Aantasting van het milieu door invloed van mensen.

epididymis bijbal
Orgaan waar zaadcellen worden opgeslagen.

erectile tissue zwellichaam
Orgaan dat zich vult met bloed bij seksuele opwinding.

erection erectie
Het stijf worden van de penis.

evolution evolutie
Ontwikkeling van het leven op aarde waarbij soorten ontstaan, veranderen en/of verdwijnen.

exhaustion uitputting
Stoffen uit het milieu halen waardoor ze opraken.

extinction uitsterven
Verdwijnen van een soort.

F

Fallopian tube eileider
Buis die een eicel vervoert naar de baarmoeder.

farm animal landbouwhuisdier
Dier dat in de veeteelt wordt gehouden.

female condom vrouwencondoom
Condoom dat in de vagina wordt ingebracht.

fertilization bevruchting
Versmelting van de kern van een zaadcel met de kern van een eicel.

flagellum zweepstaart
Staart waarmee een zaadcel zich voortbeweegt.

foetus foetus
Kindje in de baarmoeder vanaf de achtste week na de bevruchting tot aan de geboorte.

food chain voedselketen
Reeks soorten waarbij elke soort voedsel is voor de volgende soort.

food crop voedingsgewas
Plant die in de akkerbouw of de tuinbouw wordt verbouwd.

food web (food network) voedselweb (voedselnet)
Alle voedselrelaties in een ecosysteem.

foreskin voorhuid
Dunne huidplooi die de eikel bedekt.

forestry bosbouw
Land dat door de mens wordt gebruikt voor de productie van hout als brandstof en als bouwmateriaal.

fossil fossiel
Versteend overblijfsel van een organisme of afdruk van een organisme in gesteente.

fossil fuels fossiele brandstoffen
Brandstoffen die miljoenen jaren geleden zijn ontstaan uit resten van dode planten en dieren.

G

gender gender
Eigenschappen en gedragingen die mensen mannelijk of vrouwelijk vinden.

gender dysphoria genderdysforie
Zich ongemakkelijk voelen met het eigen geslacht.

gene gen
Stukjes DNA die samen informatie bevatten voor een erfelijke eigenschap.

gene editing gene editing
Het aanpassen van bestaande genen.

gene expression genexpressie
Tot uiting komen van een gen.

gene therapy gentherapie
Het gebruik van gene-editingtechnieken om kapotte genen te repareren.

genetic modification genetische modificatie
Aanbrengen van gewenste erfelijke eigenschappen bij organismen.

genomics genomics
Studie van het gehele DNA van een organisme met alle genen die daarop liggen.

genotype genotype
Informatie voor de erfelijke eigenschappen van een organisme.

geological timescale geologische tijdschaal
Tijdschaal waarin de tijd sinds het ontstaan van de aarde is weergegeven.

glans penis eikel
Top van de penis die erg gevoelig is.

greenhouse effect broeikaseffect
Verschijnsel waarbij een deel van de warmte-uitstraling van de aarde wordt tegengehouden door gassen in de dampkring.

greenhouse gas broeikasgas
Gas in de dampkring dat de warmtestraling van de aarde tegenhoudt.

H

heterosexual heteroseksueel
Je seksueel aangetrokken voelen tot personen van het andere geslacht.

heterotrophic heterotroof
Zich voeden met andere organismen.

heterozygous heterozygoot
Als een allelenpaar uit twee ongelijke allelen bestaat.

hierarchy rangorde
Relatie binnen een populatie waarbij één dier de baas is en de rest van de dieren hun plek weten.

HIV hiv
Virus dat aids veroorzaakt.

HIV inhibitors hiv-remmers
Medicijnen die de vermenigvuldiging van het hiv-virus in het lichaam remmen.

homosexual homoseksueel
Je seksueel aangetrokken voelen tot personen van hetzelfde geslacht.

homozygous homozygoot
Als een allelenpaar uit twee gelijke allelen bestaat.

hormone hormoon
Stof die de werking van organen regelt.

hormone-releasing IUD hormoonspiraaltje
Spiraaltje dat door de werking van hormonen bevruchting en innesteling tegengaat.

host gastheer
Individu dat een nadeel heeft bij parasitisme.

hymen maagdenvlies
Randje weefsel aan het begin van de vagina.

I

implantation innesteling
Het zich vastzetten van een klompje cellen in het baarmoederslijmvlies.

incest incest
Aanranding of verkrachting door een familielid.

individual individu
Één organisme.

inner labia binnenste schaamlippen
Dunne, gladde huidplooien die onder de clitoris samenkomen.

intersex intersekse
Geslacht van een persoon met zowel mannelijke als vrouwelijke geslachtskenmerken.

intimacy intimiteit
Gevoel van verbondenheid in een liefdesrelatie.

isolation isolatie
Scheiding van verschillende vormen van een soort.

K

kinship verwantschap
Een gemeenschappelijke voorouder hebben.

L

lesbian lesbisch
Als vrouw je seksueel aangetrokken voelen tot vrouwen.

levels niveaus
Schalen binnen de ecologie om relaties te onderzoeken.

libido lustbeleving
Seksueel opgewonden raken door bijvoorbeeld aanraken, strelen, zoenen of vrijen.

limits (in a sexual relationship) grenzen (in een seksuele relatie)
Dingen in een seksuele relatie die je niet wilt of niet fijn vindt.

link schakel
Elke voedselbron in een voedselketen.

loverboy loverboy
Jongen die een meisje de prostitutie in wil lokken.

M

malignant tumour kwaadaardige tumor
Snel groeiende tumor die de bouw van weefsels verstoord.

masturbation zelfbevrediging (masturbatie)
Bij jezelf zorgen voor een orgasme.

meiosis meiose
Celdeling waarbij chromosomen verdeeld worden over de dochtercellen (geslachtscellen).

menopause overgang
Periode bij een vrouw waarbij steeds minder hormonen worden aangemaakt.

menstrual cup menstruatiecup
Voorwerp dat je in je vagina stopt om slijmvlies en bloed op te vangen.

menstrual cycle menstruatiecyclus
Cyclus van het terugkerend opbouwen en afstoten van het baarmoederslijmvlies.

menstruation (period) menstruatie (ongesteld)
Afvoer van baarmoederslijmvlies en bloed via de vagina.

metastasis uitzaaiing
Het vormen van nieuwe tumoren in andere organen doordat cellen van een tumor in het bloed terechtkomen.

minerals mineraal
Stoffen in de grond die nodig zijn voor de groei van planten.

monoculture monocultuur
Elk jaar dezelfde planten verbouwen op grote stukken grond.

morning-after pill morning-afterpil
Pil met grote hoeveelheden hormonen die binnen drie dagen na geslachtsgemeenschap wordt geslikt om zwangerschap te voorkomen.

mutagenic influences mutagene invloeden
Chemische stoffen en stralingen die mutaties kunnen veroorzaken.

mutant mutant
Organisme waarbij een mutatie zichtbaar is in het fenotype.

mutated gemuteerd
Situatie waarin één of meer allelen zijn veranderd.

mutation mutatie
Plotselinge verandering van het genotype door een beschadiging in het chromosoom.

mutualism mutualisme
Symbiose waarbij beide soorten een voordeel van de relatie hebben.

N

natural enemy natuurlijke vijand
Organisme dat een insectenplaag kan bestrijden, omdat dit organisme in de natuur ook een vijand is van het insect.

natural selection natuurlijke selectie
Verschijnsel waarbij organismen die goed zijn aangepast aan hun milieu, een grotere kans hebben om in leven te blijven en nakomelingen te krijgen.

nature management natuurbeheer
Maatregelen om natuur te behouden, beschermen en herstellen.

navel, belly button navel
Litteken op de buik waar de navelstreng aan vastzat.

NIPT NIPT
Niet-invasieve prenatale test waarbij het DNA van de placenta wordt onderzocht.

nitrogen stikstof
Belangrijk mineraal in mest

non-biodegradable niet-biologisch afbreekbaar
Niet door reducenten afbreekbaar.

non-medical prenatal scan pretecho
Echo waarbij ouders de foetus alvast kunnen zien.

non-selective pesticide
niet-selectief gewasbeschermingsmiddel
middel Dat niet alleen schadelijke, maar ook onschadelijke of zelfs nuttige organismen doodt.

nutrient cycle kringloop
Manier waarop stoffen van planten via dieren, afvaleters en reducenten uiteindelijk weer bij planten terechtkomen.

NuvaRing NuvaRing
Kunststof ring met hormonen die voorkomen dat een vrouw zwanger wordt.

O

organic crop protection biologische gewasbescherming
Gebruik van natuurlijke vijanden.

organic farming biologische landbouw
Voedsel verbouwen op een milieuvriendelijkere manier dan de gangbare landbouw.

organic fertilizer organische mest
Mest afkomstig van organismen.

orgasm ('coming') orgasme (klaarkomen)
Lekker gevoel door prikkeling van de eikel van de clitoris of penis.

outer labia buitenste schaamlippen
Behaarde huidplooien om de binnenste schaamlippen.

ovary eierstok
Orgaan waar eicellen zich ontwikkelen.

over time overtijd
Niet ongesteld worden na de eerste dag waarop de menstruatie had moeten plaatsvinden.

ovulation ovulatie (eisprong)
Het vrijkomen van een rijpe eicel uit een eierstok.

P

pad, sanitary pad maandverband
Voorwerp dat je in je onderbroek plakt om slijmvlies en bloed op te vangen.

pair (of chromosomes) paar (van chromosomen)
Twee chromosomen die bestaan uit dezelfde genen.

pairing paarvorming
Samenwerking tussen een mannetje en een vrouwtje om zich voort te planten.

pansexual panseksueel
Je seksueel aangetrokken voelen tot mensen (man, vrouw, intersekse).

parasite parasiet
Individu dat een voordeel heeft bij parasitisme.

parasitism parasitisme
Symbiose waarbij één individu een voordeel heeft van de relatie en het andere individu een nadeel heeft.

penis penis
Voortplantingsorgaan van de man dat bestaat uit zwellichamen, urinebuis, eikel en voorhuid.

phenotype fenotype
Zichtbare en onzichtbare eigenschappen van een organisme.

physical change lichamelijke verandering
Verandering in de puberteit die je aan het lichaam kunt zien.

pituitary hypofyse
Hormoonklier aan de onderzijde van de hersenen die stimulerende hormonen produceert voor de voortplantingsorganen.

placenta placenta (moederkoek)
deel van de Baarmoederwand waar bloed in bloedvaten van het embryo vlak langs het bloed van de moeder stroomt.

plastic soup plasticsoep
Grote eilanden van plasticafval die in de oceanen drijven.

pollution vervuiling
Stoffen aan het milieu toevoegen die schadelijk zijn.

population populatie
Groep individuen van dezelfde soort in een bepaald gebied, die zich onderling voortplanten.

population size populatiegrootte
Aantal organismen in een populatie.

pornography (porn) pornografie (porno)
Foto's, films of teksten met het doel om seksueel te prikkelen.

precision farming precisielandbouw
Technologie gebruiken om planten heel precies te geven wat ze nodig hebben.

prenatal testing prenataal onderzoek
Onderzoek tijdens de zwangerschap om te bepalen of de moeder een grotere kans heeft op een kind met een aangeboren afwijking of erfelijke ziekte.

primary consumer consument van de eerste orde
Organisme dat producenten eet.

primary sexual characteristic primair geslachtskenmerk
Geslachtskenmerk dat al bij de geboorte aanwezig is.

producer producent
Organisme dat voedsel voor andere organismen maakt.

prostate prostaat
Orgaan dat vocht toevoegt aan de zaadcellen.

protein synthesis eiwitsynthese
Stof die voor een groot deel de kleur, vorm en werking van je lichaam regelt.

proteins eiwit
Stof die voor een groot deel de kleur, vorm en werking van je lichaam regelt .

puberty puberteit
Periode waarin een persoon lichamelijk, geestelijk en sociaal verandert.

R

rape verkrachting
Ongewenste geslachtsgemeenschap.

raw material grondstof
Stof die uit het milieu wordt gehaald om bijvoorbeeld machines, apparaten, huizen en kleding te maken.

recessive allele recessief allel
Allel dat alleen tot uiting komt in het fenotype wanneer er geen dominant allel aanwezig is in het allelenpaar

recombinant DNA techniques recombinant-DNA-technieken
Verzamelnaam voor alle technieken waarmee het DNA van organismen wordt aangepast

recycling recycling
Afval gebruiken als grondstof voor nieuwe producten.

reintroduction herintroductie
Het terugbrengen van een dier- of plantensoort in een land.

reproduction voortplanting
Het krijgen van een kind.

resistant resistent
Minder gevoelig of ongevoelig zijn voor gewasbeschermingsmiddelen.

reuse hergebruik
Een voorwerp opnieuw gebruiken.

rhythm method periodieke onthouding
Anticonceptiemethode waarbij een man en een vrouw geen geslachtsgemeenschap in de vruchtbare periode hebben.

RNA RNA
Gekopieerd stukje DNA.

rudimentary organ rudimentair orgaan (rudiment)
Orgaan dat over een lange tijd een deel van zijn functie heeft verloren en niet of nauwelijks tot ontwikkeling komt.

S

salinification verzilting
Menging van zout water met zoet rivierwater, grondwater en slootwater.

scavenger afvaleter
Organisme dat dode resten van planten en dieren eet.

scrotum balzak
Huidplooi waar een teelbal en bijbal in ligt.

sea level rises stijging van de zeespiegel
Stijging van de hoogte van het zeewater.

secondary consumer consument van de tweede orde
Organisme dat consumenten van de eerste orde eet.

secondary sexual characteristic secundair geslachtskenmerk
Geslachtskenmerk dat in de puberteit ontstaat.

sediment sediment
Laag van zand- of kleideeltjes.

semen sperma
Zaadcellen en vocht uit de zaadblaasjes en de prostaat.

seminal vesicle zaadblaasje
Orgaan dat vocht en voedingsstoffen toevoegt aan de zaadcellen.

seropositive seropositief
Besmet zijn met hiv.

sex (anatomical) geslacht (sekse)
Man, vrouw of intersekse.

sex cell geslachtscel
Cel waarin chromosomen enkelvoudig voorkomen.

sex chromosome geslachtschromosoom
Chromosoom dat het geslacht van een organisme bepaalt.

sexual assault seksueel geweld
Dwang tot seksueel contact.

sexual behaviour that goes too far
seksueel grensoverschrijdend gedrag
Ongewenste seksuele opmerking of handeling.

sexual characteristic geslachtskenmerk
Lichamelijk kenmerk waaraan je een geslacht herkent.

sexual harassment ongewenste intimiteit
Aanraking die ongewenst is.

sexual intercourse geslachtsgemeenschap
Het inbrengen van een penis in een vagina.

sexuality seksualiteit
Gedachten, gevoelens en handelingen die te maken hebben met lust en opwinding.

sexually transmitted infection (STI, venereal disease)
seksueel overdraagbare aandoening (soa; geslachtsziekte)
Ziekte die je alleen kunt krijgen via intiem lichamelijk contact met een besmet persoon.

soil pollution bodemvervuiling
Vervuiling van de bodem door giftige stoffen.

sperm cell zaadcel (spermacel)
Mannelijke geslachtscel.

sperm duct zaadleider
Buis die zaadcellen vervoert.

spontaneous (hereditary) mutation spontane (erfelijke) mutatie
Mutatie waardoor de genetische variatie in een nakomeling toe kan nemen.

sterilization sterilisatie
Ingreep waarbij een persoon onvruchtbaar wordt gemaakt door middel van een kleine operatie.

STI test soa-test
Test om te weten of je besmet bent met een seksueel overdraagbare aandoening.

sustainability duurzaamheid
Ervoor zorgen dat het milieu geen schade ondervindt van menselijke activiteiten.

sustainable development duurzame ontwikkeling
Ontwikkeling waarbij er gebruikt wordt wat we nodig hebben en toch de aarde in dezelfde staat doorgeven aan toekomstige generaties.

Sustainable energy duurzame energie
energie die geen milieuvervuiling veroorzaakt en waarbij de energiebron niet opraakt.

symbiosis symbiose
Langdurige relatie tussen individuen van verschillende soorten.

synthetic biology synthetische biologie
Vakgebied waarin biologisch materiaal kunstmatig wordt nagemaakt.

T

tampon tampon
Voorwerp dat je in je vagina stopt om slijmvlies en bloed op te nemen.

territory territorium
Gebied dat wordt verdedigd tegen soortgenoten.

testis teelbal
Orgaan dat zaadcellen maakt.

theory of evolution evolutietheorie
Theorie die ervan uitgaat dat er steeds nieuwe genotypen ontstaan, er natuurlijke selectie plaatsvindt en er nieuwe soorten ontstaan.

toxic giftig
Schadelijk voor organismen.

transcription transcriptie
Vorming van RNA.

transgender transgender
Gender waarbij de genderidentiteit niet of niet helemaal overeenkomt met het geslacht.

transgenic transgeen
Genetisch gemodificeerd organisme.

transsexual transseksueel
Als man in het lichaam van een vrouw zitten, of andersom.

trophic level trofisch niveau
Plaats van een organisme in een voedselketen.

trunk presentation dwarsligging
Ligging in de buik waardoor het kind niet via de vagina geboren kan worden.

tumour tumor
Gezwel waarin cellen zich ongeremd delen.

U

ultrasound scan echo
Beeld van een foetus in de baarmoeder dat met geluidsgolven wordt gemaakt.

umbilical cord navelstreng
Streng die een embryo met de placenta verbindt.

urban farming stadslandbouw
Voedsel verbouwen in een stedelijke omgeving.

uterus (womb) baarmoeder
Orgaan waar een bevruchte eicel zich ontwikkelt tot een kind.

V

vagina vagina
Opening die de vulva verbindt met de baarmoeder.

variants of a gene varianten van een gen
Verschillen in informatie die een gen kan hebben.

variation in genotypes variatie in genotypen
Verschillende combinaties van chromosomen.

vertical farming verticale landbouw
Gewassen kweken in bakken boven elkaar.

vulva vulva
Verzamelnaam voor de uitwendige geslachtsorganen van een vrouw.

W

water pollution watervervuiling
Vervuiling van het water door giftige stoffen.

wishes (in a sexual relationship)
wensen (in een seksuele relatie)
Dingen in een seksuele relatie waarvan je hoopt dat ze gebeuren.

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